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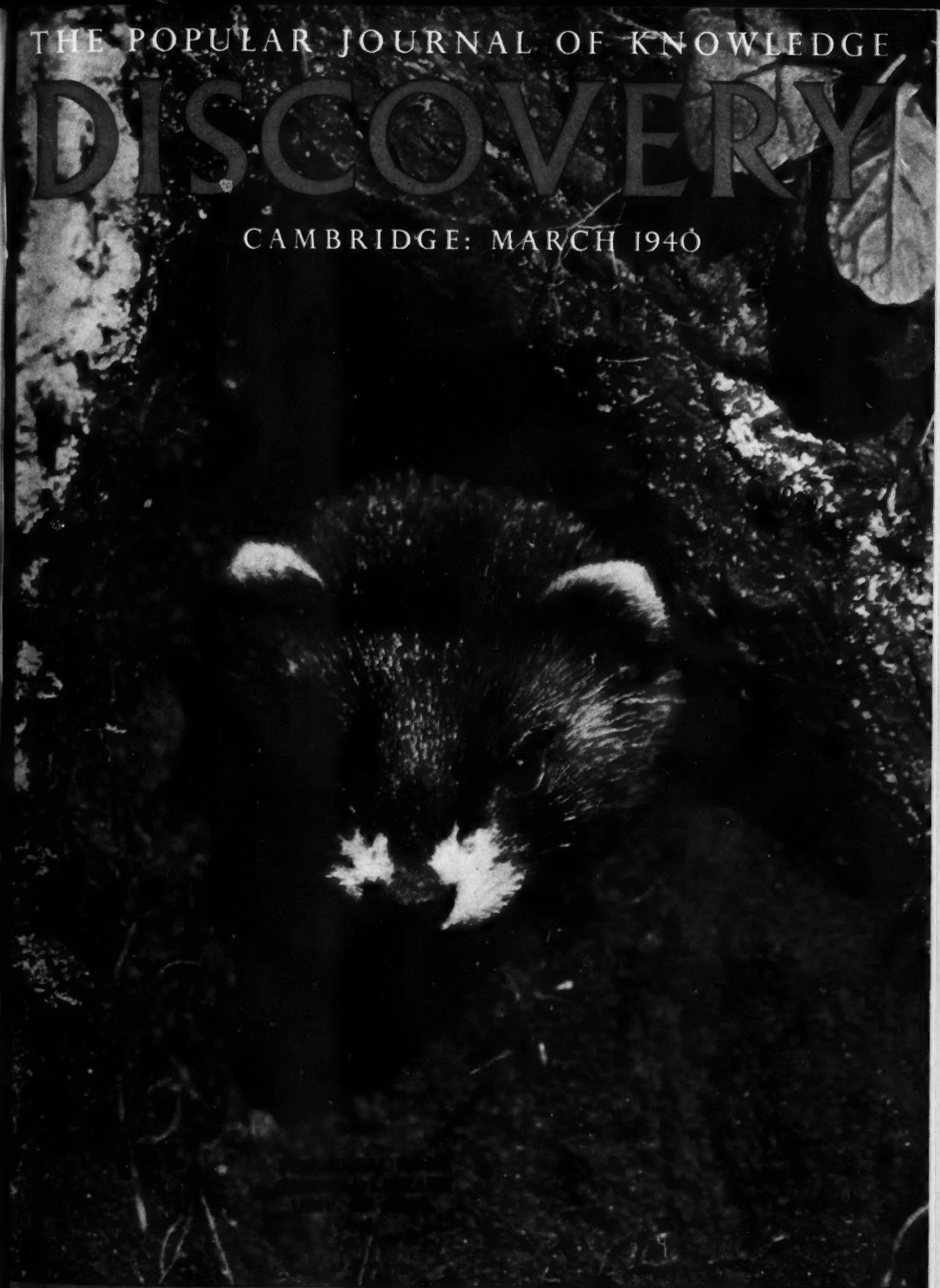

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The End of *Discovery*

WITH this issue *Discovery* has to end. It began at the end of the last war, and endured with some vicissitudes until April 1938, when it was renovated by the Syndics of the Cambridge University Press. Now, after two years in its new form and six months of another war, they have reluctantly decided that it must end.

It seems a pity. To any of us who have been concerned with the editorial side of *Discovery*, it is a personal loss to see it go; and we believe that will be true of a good many readers. But it is no use repining. Perhaps, after this war, *Discovery* will be started again, or something like it will. The only service which we can perform, while the end of *Discovery* is fresh in our minds, is to put down one or two reflections for the benefit of our possible successors.

Their first task will be to capture a larger public than *Discovery* has ever had. If it had been a sound financial proposition, it would not have stopped now; it struggled all through its existence, and though in its new form it gained twice as many readers, and four times as many subscribers, it was still a long way from paying for itself.

Now that means something: it means something, even if one thinks that good books should be published, irrespective of the money they make or lose. It means either that the public interested in the movement of science is actually rather small, or else that it has not yet been properly provided for.

It is hard to believe that the public anxious to read the news of science is really quite small. Perhaps one exaggerates its potential size because of the zest and enthusiasm of so many of its members. It was one of the most pleasant experiences in editing *Discovery* to read letter after letter from readers, full of fresh, original

interest. To them, science was something alive, part of the world's vital culture: it is difficult to believe that they form only a small fraction of intelligent people in the world to-day.

If they do not, then the others have not been reached. If that is so, a share of the responsibility rests on the editors who have tried to reach them. Where have we failed?

One gets a good many opinions. They are usually strong, because editing is a job upon which a surprising number of people hold unexpectedly violent views. The two most frequently represented to *Discovery* exactly contradict each other. The first is, that the general level of difficulty has been set much too low. One such critic suggested that all the articles ought to approximate to the standard of "Notes of the Month", i.e. the journal should be made a medium by which professional scientists might keep in touch with fields other than their own. Some critics wanted the journal mainly given over to completely detailed articles suitable for students working for their degrees. And a sort of off-shoot of this view (with a pronounced tinge of dialectical materialism) required articles of that standard, but chosen in order to stress the relation between science and technology.

These critics may be right. But they would have to convince another band, which maintained with equal certainty that the level of difficulty was kept much too high, and that the proper work of such a journal was to provide articles of the kind of our "Invitations to Knowledge".

It was our view that both these opposing schools of thought were much too doctrinaire, and that the journal could, and should, contain some articles to interest professional scientists, and others which could be read easily by a child at school. The journal, in fact, was popular among serious scientists, and we were proud of that popularity. Perhaps we leaned too much that way. At any rate, this can be said: If *Discovery* had continued, its general level would have become gradually easier rather than harder. That seemed, on balance, to fit it better for its proper purpose.

Its proper purpose would also have had to be limited. It has been called "a popular journal of knowledge"; regretfully we admit that that is asking too much for any journal in this heterogeneous world. Not many people are now interested in the world entire, and perhaps *Discovery* suffered through attempting to be too broad (although, of course, it was also criticized for being too narrow). If it had continued, we should have concentrated more on the fundamental sciences.

So, in short, our experience would have led us to make *Discovery* narrower in scope: simpler in manner (though finding writers who can simplify science truly is getting no easier).

All we hope now is that before long the same job will be tried again and carried farther.

THE EDITOR

PUBLISHERS' NOTE

To those subscribers whose subscriptions entitled them to receive issues of Discovery *after the issue for March* 1940 *a refund of the outstanding balance will be made in due course.*

The Truth About **Death Rays**

(During the past few years there have been many rumours and tales of mysterious rays which would do anything from frying an egg to sinking an ocean liner. Indeed, with these rays in existence, it would seem strange that the present war should continue to be fought with guns.

In this article, Mr D. W. F. Mayer, who has contributed several articles and notes to Discovery, *calms any possible fears by telling us of the results of scientific investigation into the subject of "Death Rays".)*

ALL the rays known to science that have any bearing on this subject can be divided into three groups. There is the Hertzian ray, which approximates slightly in properties to the magneto-stopping ray; there are rays that have a definite lethal action—though the word "lethal" must be qualified, as we shall later see; and there are rays which, while harmless in themselves, can be used for detecting aircraft or exploding mines.

The popular conception of a magneto-stopping ray is a curtain of radiation which would stop, or melt, the magneto of any aircraft passing through it. It has been found possible to do this on a small scale by using a development of the early spark wireless transmitter. This is tuned until it is in resonance with some circuit in a magneto a short distance away. When the transmitter is switched on, if the tuned circuit is ideally situated and arranged (a most unlikely state of affairs in practice), a spark can be made to jump a gap in the circuit and so shunt the magneto. By utilizing the tuned receiver circuit and spark in another manner, the transmitter can be made to set off an explosive some distance away. This system can only work when the transmitting and receiving circuits are "tuned" to each other, when there is a suitable spark-gap in the receiving circuit, and when the transmitter and receiver are not too far apart. For short-wave radio, or Hertzian waves, unlike "ideal" death rays, spread out in all directions, and cannot be focused into a beam except with great difficulty. Even then, tremendous power would be required to make them effective over a range of more than a few hundred yards. Of course, if by some miracle the true magneto-stopping ray ever did come into being, its effects could easily be overcome by the use of Diesel engines, which do not use electrical ignition.

Now for the "lethal" rays. These, again, can be subdivided into three groups. There are the rays proper, there are concentrated beams of subatomic particles, and there are high-voltage electrical discharges over ionized paths of air. In the group of proper rays, or, strictly speaking, waves, we have high-frequency sound ("ultra-sound"), and various types of electromagnetic waves ranging from short-wave radio down through infra-red and ultra-violet to X-rays. All these rays can, under suitable circumstances, be lethal, but not necessarily to human beings.

Ultra-sound waves are basically similar to ordinary sound waves, except that they have a much higher pitch, or frequency, and are thus inaudible to the human ear. As, however, they possess much greater energy than ordinary sound waves, their effect on most substances is markedly different. Thus, if they are generated in a vessel containing oil or water, portions of the liquid will be flung up, fountain-like,

and the liquid will be heated. Anyone placing his hand in the liquid would find it very painful, and would soon remove it. The force of vibration is sufficient to kill small fish or frogs. Ultra-sound, which can be produced from vibrating nickel rods, or quartz crystals, under the influence of alternating electric fields, does not spread out like ordinary sound, but travels in a beam. Beams of ultra-sound have been used for starting chemical reactions or setting off explosives. So far, there have been no cases of their producing ill effects on the human body, but mice exposed to them for a short time were found to be almost completely paralysed. In the future, perhaps, "progress" may lead to the production of more powerful and more concentrated beams of ultra-sound, which may possibly be harmful, or lethal, to human beings.

Turning now to the electromagnetic waves, we will start at the low-frequency end of the wave-band with short-wave radio and wind up at the high-frequency end with X-rays, surveying in each case the effect of the radiation on living organisms.

The radio waves used in biological experiments usually range from about 100 m. wave-lengths down to about 1 m. The organism to be subjected to the radiation is placed between two plates of a condenser, connected in a circuit driven by an oscillating wireless valve. The direction of the field between the two plates is thus reversed anything from three million to three hundred million times per second, forcing the electrons in the organism to oscillate with similar frequencies. This naturally causes the body to rise in temperature, an effect which is actually used in hospital diathermy machines (which operate on wave-lengths of about 300 m.) for subjecting patients to artificial fevers. In such cases, a weak field is used, and the temperature of the patient is rarely allowed to exceed 104° F.

If, however, the organism is subjected to shorter waves with greater power, its temperature will rise to over 300° F., well above the boiling-point of water, and death will result. In this way, Scherewsky, an American biologist, was able to kill mice and other small animals. In addition to the heating effect, there is believed to exist another lethal effect due to the setting-up of conduction currents in certain internal tissues, and so destroying them. The process has been used commercially for destroying insects and eggs in shipments of grain by subjecting the grain to short wave-lengths.

No doubt the lethal effect of these rays could be extended to human beings, but the victim would have to wait patiently between the condenser plates for half an hour or so, until he was well cooked. We can scarcely conceive this happening on a battle-field, and at present there seems to be little possibility of focusing the rays so that they can be employed without the use of condenser plates.

* * * *

Next in the electromagnetic spectrum come infra-red waves, or heat rays, for these are the rays that are given out by very hot bodies, and which warm the skin when the sun shines, or when one stands near a hot fire. Apparently their use in war dates back at least two thousand years, for a story goes that Archimedes defended the city of Syracuse against Roman attacks by constructing huge burning glasses which focused the sun's rays on the Roman boats, and set them on fire. Like light rays, infra-red rays can be focused with metal reflectors or suitable lenses, forming a beam that would burn up any person with whom it came in contact, provided it had a sufficiently powerful source. On the other hand, the beam could easily be screened from troops on which it was turned by sheets of asbestos, concrete walls, etc. In recent years a number of infra-red ray lamps have appeared on the market, and are claimed to be successful in destroying small insects.

Ultra-violet rays, the next on our list, have so slight a power of penetration that their effects on the human body are limited to the skin and superficial structures. Chemical changes in the blood are also induced, but these are due to the absorption of the radiation in the capillaries immediately under the skin. The sensitivity of a person to ultra-violet rays depends on the colour of the skin and hair, on the age of the individual, and on the time of the year when the exposure occurs. Under suitable conditions, prolonged exposure to strong ultra-violet radiation will cause reddening of the skin and painful blisters. It is doubtful, however, if such action on the human body can in any way be described as lethal, but again unfortunate insects and bacteria can be effectively eliminated.

More and more ultra-violet lamps, or sterilizing lamps as they are called, are now being used to give out mild rays which destroy the bacteria on any utensils subjected to them. Thus the lamps can be used for sterilizing drinking glasses, milk bottles, meat in cold storage, or even, in some American banks, for forming radiation screens which protect bank clerks from the coughs and colds of their patrons.

X-rays and gamma-rays, which can be classed together, are the most lethal of all the electromagnetic waves. Prolonged and concentrated radiation on all or vital parts of the human body will cause serious burns and destruction of tissue, resulting in the breakdown of essential organs, and eventually in death. We have all read accounts of the sacrifices of the early research workers in X-rays and radiology, who had to have fingers and arms amputated, or even lost their life, owing to over-exposure to the deadly X-rays, or to gamma-rays from radioactive substances. That is why radium is now stored in thick lead containers, and can only be manipulated by assistants standing behind lead screens, who use lead tongs held in special gloves. Half an inch of lead is usually sufficient to stop the radiation.

Owing to the difficulty of production, and the fact that they do not travel for more than a few yards in air, X-rays are not likely to be used for war purposes. The use of radium in war is also unthinkable, not only due to its high cost and rarity, but also to the fact that the enemy might succeed in blowing up containers of radium, thus scattering the substance over an area which it would be fatal for troops to occupy. This is one of the reasons why deep wells have been sunk near hospitals, down which radium containers may be lowered in the event of an air raid.

This completes the list of electromagnetic waves, with the exception of light waves and ordinary radio waves, neither of which are known to have any ill effects on the human body.

* * * *

We come now to beams of subatomic particles, of which there are seven types known to science. These, in order of decreasing weight, are alpha-particles, deuterons, protons, neutrons, mesotrons, positrons and electrons. Their effects on the human body are mostly similar to that of concentrated exposure to X-rays, but vary with the different penetrating powers of the particles.

Alpha-particles consist of atoms of helium deprived of two electrons, and have thus a positive charge. They are ejected from radioactive substances, and travel in straight lines with an initial velocity about one-twentieth that of light. They have only a low power of penetration, and rarely affect more than the surface cells or the blood. Deuterons are atoms of heavy hydrogen stripped of one electron, whilst protons are similarly treated atoms of ordinary hydrogen. Their effect in passing through living matter is one hundred times as great as that of the electrons generated in matter by exposure to X-rays.

Mesotrons, or heavy electrons as they used to be called, can be ignored for the moment, since they were discovered less than two years ago, and insufficient is known about them for us to consider their

effect on the human body. It is the neutron beam which, of all beams of subatomic particles, comes nearest in practice to the theoretical death ray. Neutrons have the same mass as protons, but have no charge, and can therefore penetrate heavy elements for considerable distances, since they merely bounce off the heavy nucleus of an atom of the element without loss of energy.

With light elements, however, a neutron will collide with the nucleus and impart a great deal of its energy to it, and so give the nucleus a push. In the case of hydrogen, where the hydrogen nucleus (or proton) has the same mass as the neutron, a direct collision will stop the neutron completely, and the proton will move on in its place.

Thus neutrons, unlike protons or alpha-particles, do not just produce burns on the surface of a body; they penetrate right inside until they encounter a hydrogen atom, whereupon they release a deadly proton. Rats exposed to neutrons for a day or so were found to die, exhibiting all the symptoms of severe X-ray burns. Neutrons are given off in large quantities by the massive cyclotrons which are now installed in several laboratories throughout the world, and which are used for the production of beams of subatomic particles. To protect the operators of such machines, it is necessary to surround the cyclotrons with tanks of water three feet thick, for water, being rich in hydrogen, forms an effective screen against neutrons. Deadly as the neutrons might be, the same objection applies to their use as "death rays" as applies to most other beams or radiation that we have considered—prolonged exposure is necessary for the effects to be lethal, and the apparatus required to produce them is both cumbersome and costly.

The consideration of beams of positrons (positive electrons), or of ordinary electrons, will bring us to the third of our types of lethal "rays", for a beam of fast-moving electrons is nothing more than a high-tension electrical discharge, such as an electric shock or flash of lightning. We are all aware of the lethal effects of electric shocks and lightning discharges: the question remains, can these be readily employed on the battle-field?

The answer is Yes—provided that a suitable path for the discharge can be set up. Ordinary air acts as an insulator, and some method must be found for conveying the discharge from the generator to the victim. Two methods have been suggested. In the first of these, the resistance of the air is overcome by ionizing the air along a narrow band. Such a band will carry a discharge, and may be set up by passing a beam of ultra-violet light through the air. In other words, the beam of ultra-violet light, almost harmless in itself, is made to carry a powerful electric discharge that will stun, or kill, any person with whom it comes in contact.

The other method uses a jet of water as the conducting medium. This conductive power of water is sometimes witnessed at fires, when firemen manipulating hoses receive serious shocks due to the water impinging on electric wires. Nowadays, all neon signs, etc., which employ high-voltage electricity, must be fitted with external switches, that can be turned off by the firemen in the event of a fire.

In the military method, the water would be stored in a large insulated tank, which would be charged up by electrostatic generators. The water could then be squirted at the enemy through nozzles, and any person on whom the stream was directed would receive a shock of several thousand volts. Although theoretically possible, the electrical discharge weapon would be both cumbersome and expensive, owing to the need of employing a large number of electrostatic generators. As far as the writer knows, it has never been used in practice.

Our study of "death rays" would not be complete without some reference to the use of harmless, low-power radiation for detection or control purposes in war-time. For example, the feeble heat rays given out by an aeroplane engine may be picked up by sensitive thermocouples and used to

detect the presence of enemy aircraft. In the type of instrument most widely used, the thermocouples consist of a number of junctions of two metals, one of which is bismuth, and the other an alloy of rhodium and platinum.

Such detectors have been in use for several years in astronomical observatories, for measuring the heat given out by stars or planets. So sensitive are they that they can detect the heat of a candle at a distance of fifty miles, whilst by their use some astronomers have actually prepared weather charts of Mars.

As heat waves travel at 186,000 miles per second, compared with the 1080 feet per second of sound, heat waves from an aeroplane engine can be detected long before the sound of the engine is picked up by the most sensitive sound detector. Experiments have also been made with powerful beams of these infra-red rays, which can be directed into the sky and reflected back on to detectors by enemy aircraft.

Such rays have no difficulty in penetrating fog or clouds. To an anti-aircraft crew skilled in their use, they would be almost as good as ordinary searchlight beams, yet to the pilots of the bombers the rays would be quite invisible.

Further experiments have been made, chiefly in America, using infra-red rays not only for detecting bombers, but also for destroying them. The heat rays given off by a bomber would be used to steer a small, unmanned aeroplane loaded with explosive. It is clear that such a 'plane would follow the nearest bomber discharging hot exhaust gases. However the bomber might turn and manœuvre, the fast robot 'plane would eventually overtake it, crashing into it and blasting it to pieces.

A similar device is a self-guided aerial torpedo, tuned to the sound of the enemy bomber. In such a torpedo there would be two microphones, one on each side, connected by amplifiers and relays to the rudder. When the sound was equal in intensity in both microphones, the torpedo would move straight ahead. Should the sound be louder on one side than on the other, the rudder would be automatically turned and the torpedo would change its course accordingly, until it finally reached the bomber and exploded.

This completes our survey. We have seen that of all the different types of ray known to science, only a few can be described as "lethal", and these only in concentrations and under circumstances unlikely to be encountered on the field of battle. We have avoided such things as cosmic rays, since insufficient is known about their production or effects. We must also remember that most military research is conducted in secret, and that death rays *may* exist behind locked doors. That "secret science", with its relatively few workers, should ever get so far in advance of ordinary science, with its thousands of workers, is, however, extremely improbable.

Future developments may, of course, succeed in producing some of the rays I have mentioned in concentrations and conditions which make them lethal, but this, again, is far more of a possibility than a probability. Yet in front of me as I write are a number of newspaper cuttings containing definite but undetailed reports of such things as a ray that will destroy aircraft; a ray that will disintegrate rocks; a dazzle ray invented by the French; an electric shell invented by the Russians; a death ray used in the Spanish Civil War; a ray that will make armies invisible; and a mysterious device for nullifying the effects of all poison gases! If, as I suggested at the beginning, we are to decide whether they are true or just nonsense, a fair verdict on such reports would emphatically be nonsense!

DOUGLAS W. F. MAYER

STRANGE PARTNERSHIPS

Some examples of Symbiosis where plants and animals of different species are found united for their common benefit

By H. Chapman Pincher

CERTAIN termites harbour within their alimentary canals minute organisms known as Trichonymphids, which possess the rare power of producing a ferment or "enzyme" which can digest wood. The trichonymphids can exist only within the termites, and since the latter feed entirely on wood and cannot produce the wood-digesting enzyme themselves, they are totally dependent upon their microscopical guests. This association is an example of "symbiosis", a condition which implies an intimate relationship of two organisms with resultant mutual benefit. Unfortunately the term is now used to cover a wide variety of conditions, some of which are manifestly parasitism. A relationship can be considered as truly symbiotic only when definite benefits accrue to both partners. In many so-called symbiotic associations, one partner is usually aggressive and obtains the better of the bargain at the expense of the other, and associations, which strictly fit the definition of symbiosis are rare. This rarity is explicable in the light of a study of the evolution of symbiosis.

A relationship such as that of the termites and the trichonymphids must be the result of many evolutionary stages, since at one time both partners must have been capable of independent existence, but unfortunately such stages are not represented in fossils, and therefore our knowledge of the evolution of symbiosis has to be pieced together from evidence gleaned from living examples.

Merulius and *Coniophora* are two wood-rot fungi commonly found growing together on the same substrate. Perhaps such chance associations as this represent the first stage in the formation of a symbiotic union. An association of greater intimacy is presented by the lichens, which are dual organisms, each the result of the union of an alga and a fungus. *Cladonia rangiferina*, which in the Arctic forms the main food of the Reindeer, may be considered as a typical lichen. Fig. 1 shows that the body or "thallus" of the lichen is composed of a mass of fungal threads surrounding

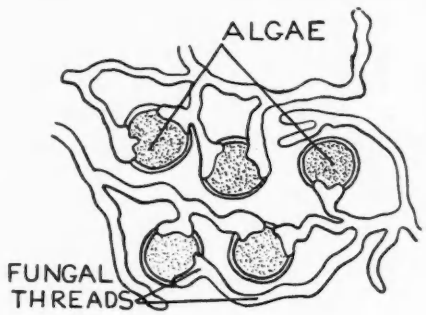


Fig. 1. *Part of Thallus of Lichen*

numerous algal cells. In a lichen association, great advantage accrues to the fungus because foods manufactured by the alga are absorbed by the fungus which in some cases pierces the cells of the alga by means of peg-like outgrowths. The fungus cannot live apart from the alga, upon which it is dependent for food, but the alga can and does pursue an independent existence. The green alga present in *Cladonia* is known as *Cystococcus* when living apart from the fungus, and it thrives much better as an individual plant than as a component of the lichen. The advantages of lichenism usually ascribed to the alga are very dubious. The fungus is said to supply the alga with essential salts and to protect it from desiccation, and there is no doubt that but for

the presence of the fungus, the alga would find difficulty in colonizing such barren places as walls and rocks, but the comparison must be made between the *normal* growth of the alga and its growth in the lichen, not between the latter and its growth in a normally impossible environment. Reproduction of the lichen is carried out solely by the fungus, and this is a great disadvantage to the alga as a species. It has been found that if filter papers are exposed in a favourable position, numerous wind-borne spores of fungi and algae settle in the corrugations of the paper, and it therefore appears that, in nature, lichens may arise by the chance association of the requisite reproductive bodies. This mode of formation, coupled with the fact that one of the partners can exist independently, indicates that lichenism is a stage far removed from true symbiosis.

Another much-discussed example of symbiosis is that association called "mycorrhiza". The term expresses the relationship between a fungus and the roots of a more highly evolved plant, commonly a tree.

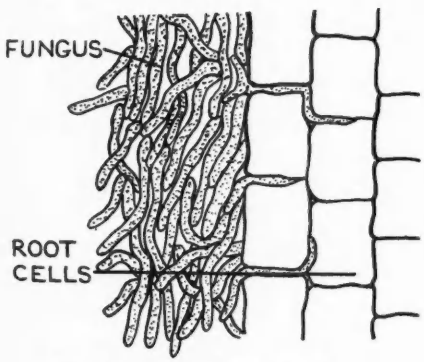


Fig. 2. *Ectotrophic Mychorrhiza*

Two types of mycorrhiza are recognized, differing in the degree of intimacy of the association. In the more superficial type, styled "ectotrophic", the fungus is restricted to the outermost layers of the root (Fig. 2). In the "endotrophic" variety, the fungal threads penetrate extensively into the inner root tissues of the higher plant (Fig. 3). The physiology of the two types is very different. In ectotrophic forms

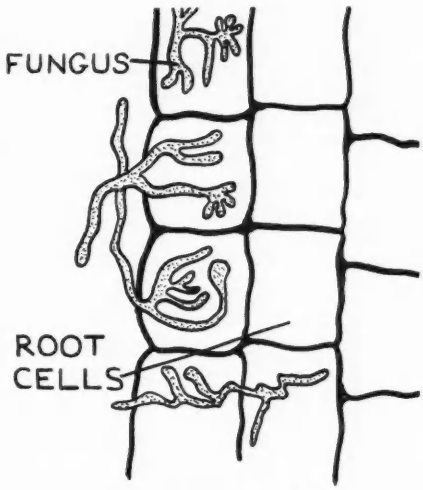


Fig. 3. *Endotrophic Mychorrhiza*

the rooted partner is usually a tree, and the fungus replaces the root hairs of its partner, absorbing water and salts and passing them on. There is no evidence that the fungus functions more efficiently than the root hairs in these respects, and the alleged absorption of phosphorus compounds by the tree from the fungus is mere supposition. There is no proved instance of the dependence of a plant upon an ectotrophic fungus, but the phenomenon is very widespread, and it seems definite that certain orchid seedlings obtain benefit from the fungus during early life by the absorption of organic matter from the soil. All attested work tends to show that ectotrophic mycorrhiza is a case of controlled parasitism, the fungus benefiting by the absorption of food from the rooted plant. It is certainly so in some endotrophic forms, for if a weak seedling of the heath *Calluna* be inoculated from a strong culture of *Phoma*, which is the fungus normally present, the plant is strongly parasitized.

In endotrophic mycorrhiza, the fungus is commonly digested by the root cells into which it penetrates. This digestion is especially well shown in the case of a fungus associated with a species of *Eriostemon*. The external threads of the fungus absorb organic matter from the soil and pass it to the internal threads, where, together with material absorbed by the fungus from its host, it is converted into fat and stored. The internal threads ultimately burst and their contents are absorbed by the protoplasm of the infected root cells. This digestion of the fungus provides the plant with an easy method of nitrogen absorption, for the walls of the fungal threads are rich in nitrogen. This is especially true of the fungus *Phoma*, which is capable of converting atmospheric nitrogen into available nitrogen compounds. In endotrophic forms it therefore appears that the rooted plant is to some extent parasitic on the fungus, and cases where plants have become totally dependent upon their mycorrhizal fungus are to be expected. The Orchid, *Gastrodia elata*, provides such a case. Tubers constitute the body of this plant, and only those tubers associated with the fungus *Armillaria mellea* can produce flowers. Ordinarily, *A. mellea* is a very devastating parasite, but in the orchid tuber it is rapidly digested, and the extra nutriment thus obtained enables the tuber to produce a flower the following spring. Uninfected tubers dwindle away and die.

Those flowering plants classed as "saprophytes", i.e. organisms living by the absorption of dead organic matter, represent extreme instances of the mycorrhizal relationship. *Corallorhiza* (Coral Root) (Fig. 4) and *Neottia* (Bird's Nest Orchis) are examples of British saprophytic plants. *Neottia* possesses a little chlorophyll, but *Corallorhiza* is entirely without this pigment, and is therefore absolutely dependent upon the organic nutriment absorbed by the fungus which is in association with its roots. Excluding bacteria, ectotrophic mycorrhiza is the nearest approach to true symbiosis in associations between two plants. This is the result of attempted parasitism, and in endotrophic mycorrhiza, the tables have been turned so that the rooted plant exploits the fungus. In *Gastrodia* this exploitation has proceeded so far that flowering is dependent upon the presence of the fungus, and in forms such as *Corallorhiza* and *Neottia*, total dependence for food supply has ensued.

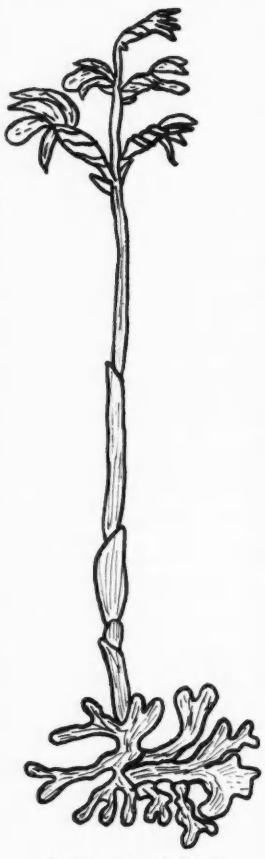


Fig. 4. Coral Root

Bacteria of many species are present in the alimentary canal of man. Normal adults excrete about 30 billion daily, a figure which gives some indication of the terrific amount present in the intestines. Some of these bacteria are absolutely harmless and confer no benefits to their host. The association of such bacteria with man is a chance relationship at about the same evolutionary level as the association between *Merulius* and *Coniophora*. Other intestinal bacteria, in addition to their presence being of no benefit to man, produce substances which may act as irritants, causing diarrhoea. In this case, although the bacteria can hardly be classed as parasites, the relationship is one-sided and all in favour of the bacteria, which are

provided with abundant food supplies and a suitable environment at the right temperature. A few particular species of intestinal bacteria produce enzymes capable of digesting cellulose, and as a result of their activity, a certain amount of the food which would otherwise be wasted is made available to their host. This association is more or less symbiotic, though the evil effect of the toxins produced by these bacteria probably outweighs the benefits of the extra food. However, in herbivorous animals, which feed almost entirely upon cellulosic foods, the presence of these bacteria is essential, and it appears that the alimentary canal of some ruminants has become structurally adapted to favour bacterial action. This association may be regarded as definitely symbiotic.

The well-known association of bacteria with leguminous plants is also truly symbiotic, and the relationship is very intimate. The leguminous seedling is at first uninfected by the bacterium (*Pseudomonas radicicola*), which is normally present in the soil. The root hairs produce a liquid which stimulates the bacteria in the soil around, and, in turn, the bacteria secrete a liquid which causes the root hairs to curl. At the bend where each hair is weakened, the bacteria enter and multiply. As a result of the bacterial irritation, a nodule is formed on the plant, and henceforth the bacteria are confined to this outgrowth. *Pseudomonas radicicola* possesses the remarkable property of being able to convert atmospheric nitrogen into nitrates, some of which are passed from the nodule into the plant, which thereby benefits. In addition to a suitable environment, the bacteria obtain an ample supply of carbohydrates from the plant, and thus the relationship is mutually beneficial. This happy state of affairs is not far removed from parasitism, however, for under certain conditions the bacterium can attack the substance of the plant. But this is not to be wondered at, for *Pseudomonas radicicola* is very closely related to the bacteria which cause such diseases as Bean Blight and Black Rot of cabbage.

Many luminescent animals are believed to contain symbiotic bacteria to which they are said to owe their light-producing powers. This contention is very doubtful, since nearly all cases of bio-luminescence have been proved to be the result of the action of chemicals, produced by the animals themselves, with the oxygen of the air.

A good deal of experimental work has been performed on the subject of the evolution of symbiosis in cases of relationships between plants and animals. The plants concerned are unicellular algae, and nearly all the animals are aquatic forms. Under experimental conditions, sponges can be made to take in the alga *Pleurococcus*, the latter being able to exist within the body of the animal. If the protoplasm of the sponge becomes starved, however, the algae are ingested. If this occurred in nature, it would be interpreted as an unsuccessful parasitic attack by the alga. Spontaneous infection has been observed in *Hydra vulgaris*, and the immediate result was the development of the symptoms of parasitism by the animal. In other hosts, in other species of *Hydra* for example, the algae are more resistant to ingestion, and are killed only under extreme conditions of hunger. In the cases so far mentioned, there is definite mutual advantage to the participants of the associations, since the animal in each case benefits by carbohydrates produced by the plants in photosynthesis, and the plants receive a good supply of salts and carbon dioxide, both raw materials for the building up of carbohydrates. But in none of these cases is there any dependence of one partner upon another, both being capable of independent existence. As a result of some associations, the animal may become totally dependent upon the plant; as a result of others, the reverse occurs. An example of the former condition is to be found in the relationship between a flatworm, *Convoluta*, and an alga called *Carteria* (Fig. 5). The worms normally become infected by the alga shortly after

hatching. If uninfected, they soon die, for they have no mouth and cannot feed other than by absorption of the food produced by the algae in photosynthesis. Shortly after ebb-tide, the adults may be found forming dense green masses on the beaches of the Channel Islands, where the contained algae absorb as much sunlight as possible, disappearing just before the next high tide. The alga is quite capable of independent existence, but within the worm

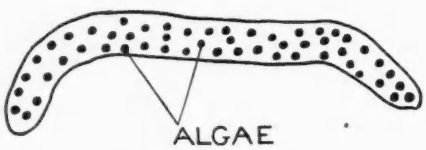


Fig. 5. Convoluta

it finds a copious supply of carbon dioxide and salts. Although the alga is the active partner in the first infection, the worm is the aggressive member of the union, since sooner or later the alga is ingested by the animal, which dies from starvation as a result. In certain corals and clams the algae are dependent upon the animals, and are never found leading an individual existence. They are never ingested by their hosts, and, like many parasitic forms, have lost the power of sexual reproduction, but the associations are truly symbiotic, for the alga obtains the raw materials for photosynthesis, whilst the animals profit by a supply of carbohydrates and oxygen and by the removal of salts which are in the main excretory products.

All the animals so far considered in these associations are invertebrates, and cases of symbiosis involving a vertebrate are very rare. The classic example is the association between a South American Sloth (*Bradypus*) and a unicellular alga. The plant lives in grooves on the hairs of the sloth, which thus assumes the greyish green colour of the plant *Tillandsia*, a common growth on the trees that constitute the home of the animal. This association was no doubt originally a chance relationship that has been perpetuated as a result of natural selection, a contention that is supported by the peculiar distribution of the sloths.

In a very few cases of plant-animal symbioses, both partners have become totally dependent upon each other. This is so in the association of the *Yucca* tree and the *Pronuba* moth. The female *Pronuba* has mouth-parts structurally adapted to the collection of *Yucca* pollen, which it works into a large ball that is stuffed between the stigmas of the *Yucca* flower. In addition, the moth lays one or more eggs in the ovary of the same flower. The larvae feed upon the young seeds, but plenty are left untouched for dispersal. *Yucca* seeds are the only diet upon which the *Pronuba* larvae can thrive, and without the activity of the moth pollination is almost an impossibility in the *Yucca*. The relationship is even more remarkable, for in the years when *Yucca* does not flower the moths remain dormant in the pupal stage. Perhaps the same set of conditions which determines the rather irregular time of flowering of the *Yucca* also controls the emergence of the moth from the pupa.

Associations between two animals are common, especially in the case of marine organisms. The association may be very superficial, one animal merely following another for food or protection. Thus the Pilot Fish is usually to be found in attendance on sharks, consuming the parts of the prey left by the predatory fish. Even such superficial relationships as these may result in the development of structural adaptations; for example, in the Remora, which also accompanies the shark, the dorsal fin has become changed into a sucker by means of which it attaches itself to a shark, so as to be always on hand for food. The Pea Crab, which has a similar relationship with the Common Mussel, actually lives within the shell of the latter, removing nutriment which would otherwise feed the mollusc.

These relationships are not very intimate and are all one-sided, but it is common for such external associations to become bene-

Fig. 6. Hermit Crab and Anemone

ficial to both partners, when the condition is called "commensalism", which means "eating at the same table". Commensalism may be regarded as incipient symbiosis, and the well-known association between the Hermit Crab and a Sea Anemone is a good example (Fig. 6). The crab benefits by the concealment of the shell in which it lies, and the anemone obtains scraps of food accidentally set free into the water by the crustacean during feeding. The *Dromia* Crab favours a sponge rather than an anemone, and it holds it on to its shell by means of a pair of specially modified legs. The *Melia* Crab carries an anemone in each great claw, and, if attacked, it thrusts them at its enemies, relying on the stinging cells of the polyp for protection. In addition, the crab abstracts food from the stomach of the anemone, which is thus at great disadvantage in this partnership. Commensalism may become

very intimate as in the association between the Common Wasp and the larva of the Girdled Drone Fly. The excretions of the wasp larva collect during larval life and are not shed until the last moult. This unpleasant matter is removed from the cells of the comb by the larva of the Girdled Drone Fly, which lays her eggs within the comb. Neither the larvae nor the adult flies are harmed by the wasps, which would attack any other intruder to the nest. A similar case is found in the association between the young whiting and the Jellyfish, *Cyanea*. At the first sign of danger, the tiny fish take refuge within the cavity of the jellyfish, probably enticing prey within reach of the tentacles of the latter.

An example of true symbiosis with mutual interdependence has already been given in the association of trichonymphids and termites.

Of the many associations considered above, few have conformed with the strict definition of symbiosis, which demands that there shall be mutual benefit. Many associations popularly classed as symbiotic are seen to be cases of parasitism. The parasite may be successful, as in the case of the lichen fungus, tolerated, as in ectotrophic mycorrhiza, or so unsuccessful that the attack is converted and the would-be parasite parasitized, as in endotrophic mycorrhiza. In those cases where symbiosis definitely exists, it is often due to a fortuitous circumstance; for example, the non-digestion of the symbiotic algae in corals is due to the fact that the plants possess a thick cellulose wall, a feature significantly absent in such forms as *Carteria*, which undergo digestion by their hosts. In cases of very intimate symbiosis, the association is probably the result of many evolutionary steps, each of which has been perpetuated by natural selection, since they proved of advantage to both participants of the union. Even in very intimate cases of symbiosis, however, the balance is easily upset, so that one partner becomes aggressive, as in the case of bacteria and leguminous plants.

Of late there has been a tendency to regard almost any association as symbiotic on the flimsiest evidence. Because of the common occurrence of green unicellular algae within invertebrates, it has been seriously suggested that in all green plants, the chloroplasts, those tiny bags of chlorophyll found in the leaf cells, are symbiotic algae, and that certain rod-like bodies found in the protoplasm of nearly all cells are symbiotic bacteria.

Such suggestions as these, based, as they are, purely on speculation, deserve scant consideration.

Seals' Breeding Habits

By Dr COLIN BERTRAM

Some mammals are strictly monogamous, many are promiscuous or casually polygamous as circumstances allow. But very few species of mammals are strictly polygamous, the females being herded together in groups, each dominated by a single male who actively keeps watch over his harem and fights off all encroaching fellow males. Certain of the seals, however, exhibit this habit to an extent that is probably greater than in any other animals, and with it go very striking modifications, both morphological and temperamental. The Pinnipedia or seals are divided into three main groups, the Eared Seals, the Walruses and the True Seals. The Walruses, so far as is known, are monogamous or quietly promiscuous animals with a gentle

Skull of an old male Weddell Seal from Grahamland in Antarctica. Note the broken teeth and necrosed condition of the palate, resulting from excessive wear in sawing ice to keep open breathing holes in the winter

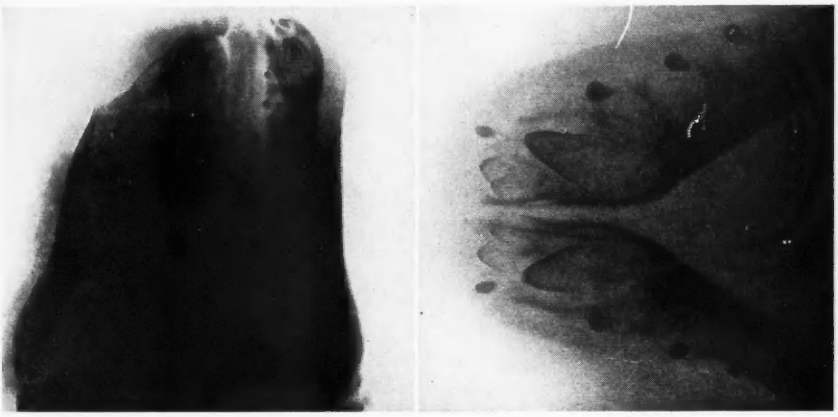
temperament and peaceful habit until disturbed by man. Likewise, nearly all species of True Seal are relatively good tempered, and the fact that they mate in the water is clearly likely to allow a wide freedom in their sexual relationships. In such species, though they may be somewhat larger than the cows, there is really not much fighting between the individual bulls. In the four truly Antarctic species of True Seals, the females are slightly the larger. But in all the Eared Seals and one species of True Seal (the Elephant Seal), a very different state of affairs exists. Among all these species, the whole sexual life takes place on land, the harem system has been developed to its fullest among mammals, and with this extreme polygamy goes its invariable concomitant, a great sexual disparity in size and temperament.

To get a complete idea of the polygamous system at its highest development, consider the life and habits of the Northern Fur Seal, the species that breeds in Bering Strait, has been the subject of international treaties, and provides the soft, velvety "sealskin" of commerce. These animals, besides their other remarkable characteristics, migrate annually a greater distance, perhaps, than does any other mammal, not excluding even the great whales of the Southern Ocean. The Northern Fur Seals breed only at the Pribilof Islands off the coast of Alaska. On the beaches of those islands the animals haul out in countless thousands in the spring to breed. Later in the year they leave the north and move southwards, some even reaching the coast of California. Thence in the following spring they move all those thousands of miles northwards again to the fogbound rookeries of the Pribilofs where their comings and goings are carefully watched and guarded by the U.S. authorities who control the fishery.

First of all the adult bulls, seven years of

age and older, come ashore. There each one takes station at a little distance from his fellows, and stakes his claim. Soon the full-term females, three years old and upward, leave the sea and mount the beaches. As they come up, they cross the territories of the bulls, and these attempt to herd the new arrivals each into his own harem. Very soon after leaving the sea, the 11½ months' gestation comes to an end, and each female gives birth to her single pup. The pup at first weighs only a few pounds, has a quaint small bleating voice, and at once starts sucking. About ten days after her pup is born, the cow is willing to receive the bull again, and his strength and sexual capacity are very great. A bull in his prime may manage to retain an harem of even seventy cows, covering them all and fighting off all rivals. In actual practice at the Pribilof Islands, where 50,000 three-year-old bulls are killed each year for their pelts, the average harem throughout the rookeries is made up of about forty cows.

The male and female pups are born in roughly equal numbers, so that one bull having many cows means that many bulls have no cows. Hence the constant fighting that goes on throughout the breeding season among these polygamous seals. The bachelor bulls are very naturally jealous of the harem owners, and constantly try to poach the outlying cows. Even though in some species much of the fighting between the bulls may be based on bluff, it requires constant watchfulness on the part of the harem master. The result is that throughout the breeding season, for seven or eight weeks, the harem bulls can never for a moment leave the land and go to sea, and therefore during the same period the big bulls must starve completely. No wonder that by the end of the breeding season when they return at last to feed, the great sleek bulls of two months before are thin, scarred, and emaciated.



X-ray pictures of head and lower jaw of 50 cm. Weddell Seal foetus, showing the reabsorption of the milk dentition and appearance of the permanent teeth

Among seals, as indeed among all mammals, sexual disparity in size in favour of the male is a constant and parallel concomitant of the polygamous habit. Few are willing to accept the obvious deduction that the human male was intended by Nature to be a bigamist at the very least. The connexion between sexual disparity in size and temperament and the polygamous way of life is very obvious, but

Photo: Brian Roberts

Cow Elephant Seals at South Georgia with their new-born pups

which, the system or the disparity, was causal, and which resultant, cannot with certainty be stated. Clearly, once the evolution of the harem system has started, there will be a strong positive selection in favour of increased male size and pugnacity. Likewise, since the females may be bandied about between the teeth of rival overlords, a decrease in female size and a great submissiveness in temperament will be of selective value. So it comes about that in the most highly polygamous species, the Northern Fur Seal and the Sea Elephant, the adult male may be so much as six times the size of the adult female. If among humans there were a comparable disparity, a normal well-grown male would be perhaps 10 ft. in height and weigh some 50 stones, an obstinate and pugnacious tough; his wife, or rather wives, would morphologically be as women are to-day, but temperamentally like very few, ever quiet, obedient, and submissive.

For comparison with these polygamous seals, take the Weddell Seal as an example of the True Seals. The Weddell is the most southerly ranging of all mammals apart from man himself, and lives along the coasts of the Antarctic continent and nearby islands. The animal is very well adapted to its watery habitat, and is sluggish on land or on the ice. It grows to a length of about 9 ft., the females being slightly bigger than the males. During the winter and spring, when the fjords and bays are covered with ice, the Weddell seals live in the sea beneath the ice, and must perforce by constant effort keep open breathing holes to the air above.

In the spring the females leave the water and haul out on to the ice to pup, either singly or in groups. The pup at birth is 4 ft. long and clothed in a thick woolly coat, quite unlike the straight smooth hair of its mother. The pups of all seals are very well advanced at birth, and this is particularly so among True Seals like the Weddell. The

new-born pups of the Eared Seals will usually drown if put at once into the water, but among the True Seals this is not so, though normally the pup will not enter the water until a few weeks old. But the pup of the Common Seal is frequently born on a sandbank and must swim at the first high tide after birth. In readiness for such an event, the woolly infant coat, in this species, is moulted even before the pup is born. In the Weddell, as in most True Seals, the woolly coat lasts the period of suckling, which is limited to a few weeks, and then the pup must take care of itself. Presumably because of this early need for self-support, some of these seals have a remarkable adaptation. The milk teeth, instead of being used for a period in early life, are greatly accelerated in their appearance, reaching their maximum size at about half way through foetal life. They never become functional, and are quickly reabsorbed. The adult dentition is ready for use very shortly after birth.

Though so soon to begin life on its own, the pup is given a good start by the mother. The Weddell pup at birth weighs about 60 lb., but at the end of a fortnight may weigh over twice as much, and may be gaining weight at the astonishing rate of over 7 lb. each day. Then at about six weeks of age the maternal milk supply begins to fail, and there is a marked decrease in the pup's weight until it learns to catch for itself the fish and squids that form the adult diet.

Thus there is among seals a general tendency to compress as much as possible of the whole development into the 10 or 11 months of foetal life, leaving little more to be done before the young animal can fend for itself. This would seem an obvious advantage in an animal whose whole evolution is tending to cut it off more and more from dependence on the land. In the Crabeater and Common Seals the evidence, though meagre, suggests that lactation is limited to a few days only, so that these are the mammals in which parental care is reduced to a minimum.

After H. W. Elliott

Northern Fur Seals. Harem bull, cow and pup. Probilof Islands

The Coming of the Electron

"Wherever electricity is the servant of man, electrons are responsible." Dr A. K. Solomon, who described the Cyclotron and the Cloud Chamber in Discovery *last year, tells the story of electricity from the first definition of positive and negative to the controlled flow of electrons in the modern radio valve.*

BENJAMIN FRANKLIN was astute. His sagacity and keenness of discernment are evident in many of the observations he made about the nature of "electrical fire". Although the kite experiment is probably the most famous Franklin experiment, it was not undertaken until 1752, by which time he had already established a considerable reputation. Even in those days the calling of a physicist was not without its dangers: Professor Richmann was killed in St Petersburg in 1753 while repeating the kite experiment. Franklin himself received several electrical shocks, one especially intense, in his experiments on electrocuting fowl. These fowl he killed by the discharge of several Leyden jars connected in cascade; describing the experiment, he writes: "As six jars, however, discharged at once are capable of giving a very violent shock, the operator must be circumspect lest he should happen to make the experiment on his own flesh, instead of that of the fowl."

Generating electricity in the most primitive fashion, by the friction of a piece of silk rubbed over a glass rod, Franklin was able to carry out some very important experiments. He defined positive and negative electricity according to a convention which is still in force. He was aware of the fundamental and well-known law which states that particles with opposite charges attract and particles with like charges repel one another, and he described an experiment which illustrated this law: "When a body is electrised *plus*, it will repel a positively electrified feather or small cork ball. When *minus*, it will attract them."

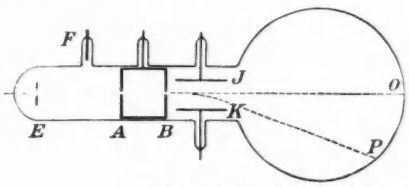
It was natural to expect that a man of Franklin's inquisitive turn of mind would devise an explanation of the phenomena he observed. Accordingly he suggested that electricity was a fluid: positively charged matter contained an excess of the fluid, negatively charged matter lacked it. Thus began a century and a half of controversy, while scientific discussion raged on the nature of electricity. It was not a fruitless interval, because many of the laws describing electricity were then first adequately formulated. None the less, scientists were unable to decide just what electricity was. One school held Franklin's theory of the single fluid, another school, more numerous by far, felt that there were two fluids, one positive and one negative. There were even those who felt that electricity might be corpuscular, a theory supported by some interesting experimental evidence. By the end of the nineteenth century, the body of knowledge regarding electricity had become far more complete. Electricity could be described, could be generated, and even accurately measured, yet the question still remained, "What *is* electricity?" Finally, in 1897, Professor J. J. Thomson, working at the Cavendish Laboratory in Cambridge, England, gave the first definite answer. Electricity was particles.

It was not a new suggestion. During the century of controversy, it had been put forward time and again. Thomson's work was important because, in his experiments on the conduction of electricity through gases, he proved that electricity was corpuscular.

To-day the conduction of electricity through gases is demonstrated practically by neon signs. Electricity flows between two metal plates called electrodes at either end of a gas-filled tube. If almost all the gas should be removed from the tube, electricity would still flow, carried by Thomson's particles, electrons. Some properties of the particles responsible for the flow were already known. The electrons had negative charge and they were propagated in a straight line from the negative electrode, regardless of the position of the positive one. Being charged, the rays possessed two further properties: the beam could be deflected both by a positively charged electrode and by a magnet.

In his experiments Thomson used a glass tube, flared out at one end. With the gas almost entirely removed, electricity flowed between the two electrodes. Halfway down Thomson's glass bulb, just where the neck flared out into the body, he placed two additional parallel electrodes to deflect the beam. When these were uncharged, the beam passed between them and caused a bright spot of fluorescence on a screen at the end of the tube. As soon as the electrodes were charged, the spot moved and came to rest on a different part of the screen. A small electromagnet placed outside both the tube and the electrodes could be used to counteract the deflection of the beam. Carefully balancing the voltage on the electrodes and the current through the electromagnet, Thomson was able to restore the beam to its undeflected position. From the values of the voltage and the current and the observed arrangement of plates and electromagnet, he could calculate at once the velocity of the particles.

But the velocity was not information enough. It remained to know the mass and the charge of the particle. Thomson's experiment could not provide these two values independently; however, from a knowledge of the deflection caused by the magnet alone, he could calculate their ratio. The ratio of the charge to the mass of the particles, called e/m, is a constant independent of the nature of the gas that had filled the tube, and independent of the metal used for the electrode. With this knowledge, it was established that electrons were corpuscles with a finite charge and a finite mass. The flow of electricity was a flow of particles.



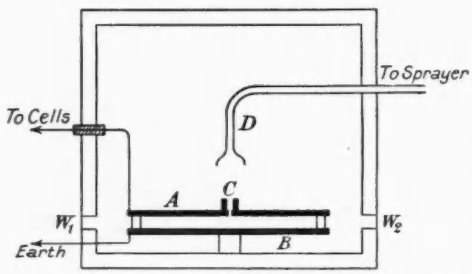
From Crowther: Ions, Electrons, and Ionizing Radiations.

The negative electrode E *emits a stream of electrons,* F *is the anode,* A *and* B *are diaphragms to define the electron beam,* J *and* K *are the deflecting electrodes,* O *represents the point where the undeflecting beam comes to rest,* P *the point where the beam comes after deflection. A magnetic field is applied by a magnet placed with its poles at right angles to the plates* J *and* K

To establish the unique nature of the particles, it was necessary to measure either their charge or their mass directly. With particles so tiny, carrying so small a charge, either of the determinations was bound to be very difficult, and, once a suitable method had been devised, to require painstaking and accurate work. Under Professor Thomson's direction, experiments had been undertaken to estimate the charge by measuring the attraction of a charged water cloud toward an electrode. Evaporation of the cloud during the experiment made the results inaccurate.

In 1909, Robert Millikan at the University of Chicago began experiments designed to overcome this error. He wrote: "My original plan for eliminating the evaporation error was to obtain, if possible, an electric field strong enough exactly to balance the force of gravity upon the cloud. It was not found possible to balance the cloud, as had been originally planned, but it was found possible to do something much better: namely, to hold the individual

charged drops suspended for periods varying from 30 to 60 seconds." To make the drop visible, the space between the electrodes was brightly illuminated and the drop itself observed through a small telescope. Millikan says: "These drops appear as perfectly distinct bright points. I have on several occasions obtained but one single such 'star' in the whole field and held it there for nearly a minute."



From Crowther: Ions, Electrons, and Ionizing Radiations

Millikan's apparatus for the exact determination of the charge on an electron. D *is the outlet for the oil drops,* C *is the hole in the top plate,* A *and* B *are the two parallel electrodes,* W_1 *and* W_2 *are the windows for observation*

Since these water droplets also evaporated, Millikan used oil droplets to eliminate the error completely. The chamber in which the movement of the drops was observed consisted of two parallel electrodes set a short distance apart, carefully shielded against any stray currents of air. The droplets were sprayed by a common atomizer as a mist into a chamber above the top plate. Some of the droplets penetrated through a tiny hole in the plate to the observation chamber below. The voltage on the electrodes could be set to hold the drops stationary or to attract them slowly towards the top plate. Friction in ejection from the atomizer charged the drops; in fact, Millikan soon found that the droplets often captured or lost charges during observation in the chamber.

To find the size of the drops, Millikan timed the rate of their free fall under gravity. The experiment was so painstaking, and the results so exact, that a new check had to be made on the laws relating to such fall, and a new determination made of the viscosity of the air. He found at once that the weight of the electron was negligible compared even to the weight of so tiny a droplet. The rate of fall remained constant whether the oil drop carried one or twenty-two electrons. Knowing now the size of the drop, Millikan next timed its rise when the application of voltage to the plates formed an electric field in the region between them. Long observation of a drop gave a value for the change in speed before and after capture of a single charge. It was immediately evident that the charge calculated from this data was always constant. Whether the droplet was charged by friction, or whether it picked up charge from the air, a given droplet always possessed an integral number of charges, and each charge had identical value. Millikan's meticulous work was the final proof that electricity was atomic by nature.

Determination of the electronic charge was important not only for increased physical knowledge, but also for the practical part electrons play in our daily life. In physics, the charge on the electron is a fundamental constant, because it is the irreducible element of charge. All charge, positive and negative, is atomic, and the absolute value of the charge on the electron gives the size of the indivisible electrical unit. In practical life electrons are equally important. The electron is a constituent of all matter, and exists almost universally. The chemical properties of matter depend exclusively on the arrangement of electrons in matter. The transport of electrical power through wires is the transport of electrons. When current flows through a wire, what is meant is that there is a flow of electrons through the wire. When light is kindled by the touch of a switch, there is a flow of electrons through the bulb. Wherever

electricity is the servant of man, electrons are responsible.

Nowhere is their action more apparent than in radio and television. The picture painted on the end of a television tube is painted there by an electron beam. The movement of the beam, as it sweeps up and down, over and across the screen, is controlled by electric fields, exactly like the beam in Thomson's early tube. The sole difference is that the electrons are given off by a hot filament, a small wire coil heated by electricity like the coils in an automobile cigarette lighter. Since a hot filament in a vacuum will give off electrons much more readily than a cold one, television tubes, as well as radio tubes, use hot filaments to provide the electron source. The electrically controlled flow of electrons in radio tubes is responsible for the amplification necessary for the operation of modern phonographs and wireless. Everywhere in our daily life we are dependent on the "electrical fire". The electron is ubiquitous.

The charge on the electron is $1{\cdot}59 \times 10^{-19}$ coulombs, and its mass is $9{\cdot}035 \times 10^{-28}$ grams. The first five chapters in Millikan's own book, *Electrons* (+ *and* −), give a fascinating account of the subject.

Notes of the Month

IS SACCHARIN HARMFUL?

(*A note on saccharin as a sugar substitute appeared in "Notes of the Month", Vol. II, No.* 21)

SOME biochemists claim that saccharin has detrimental effects, when taken with any regularity. They point out that, when concentrated, saccharin acts as a disinfectant similar to carbolic acid (phenol), and that it decreases the activity of enzymes. As enzymes play a considerable part in the chemical processes of the human body, especially in digestion, they hold that saccharin decreases the appetite, slows down the action of the digestive juices, and has other ill effects.

Before the last war, the view was strongly held that saccharin was an injurious drug. One French chemist went as far as to suggest that children, the sick and the aged should abstain from its use, and that it should be omitted from medicines. In Germany, legislation in 1898 and 1902 discriminated against saccharin and similar substances, and treated them almost as poisons. Great War conditions caused the German government to change its mind, and saccharin was looked upon as an aid in times of need. In the years 1917–19 about 1000 tons of artificial sweetening agents replaced some 300,000 tons of sugar. It is significant that no injurious effects on health were ever traced to their use.

Since then a large number of experiments have been carried out in which quantities of saccharin have been fed to rats, dogs or

men over considerable periods of time, and any abnormal effects noted. The experiments all show that, in quantities well in excess of those normally consumed, saccharin has no effect on gastric digestion, on the utilization of proteins or vitamins, or on the amount of sugar in the blood. When saccharin was fed to dogs in large quantities (21 grams spread over 100 days), no changes were detected in the intestines, stomach and spleen, and only very slight changes were detected in the kidneys, lungs and liver. Some biochemists claim that saccharin has a depressing effect on the heart, whilst others believe that, after prolonged standing, it loses much of its sweetness, develops an unpleasant bitterish taste, and then becomes a stimulant. Nearly all, however, are agreed that, in the small amounts usually consumed, saccharin is entirely innocuous.

Perhaps the best example of this is the case of a nine-year-old boy who, some years ago, ate 200 saccharin tablets in one afternoon. The tablets contained a total of 3·5 grams of pure saccharin. He lost consciousness for a short time, and developed hallucinations, delirium, and a skin condition resembling nettle-rash. In spite of the massive dose, the symptoms were all of a transitory character, and recovery was rapid. D. W. F. M.

PASTEURIZATION OF MILK

THE latest contribution to the pasteurization controversy has brought considerable support to those who claim that the production of a safe milk by pasteurization does not appreciably affect its nutritive powers. The National Institute of Research in Dairying in Reading has just concluded a large-scale experiment with 8000 schoolchildren. They were divided into four groups, and each group received for a year an extra ration during school hours. The first group were given biscuits, the second $\frac{1}{3}$ pint of pasteurized milk, the third $\frac{2}{3}$ pint of pasteurized milk, and the fourth were given $\frac{2}{3}$ pint of raw milk. They were all very carefully and thoroughly examined periodically throughout the year. The results showed that all three groups of children who were given milk showed an increase in weight, height and strength, and also in their ability as tested by their teachers, greater than those who had been given biscuits. There was a slightly greater improvement in those who had $\frac{2}{3}$ pint of milk than those who had only had $\frac{1}{3}$. But there was no difference between those who were given raw milk and those given pasteurized milk. Tests were also made with a large number of calves, and here too no significant difference could be detected between animals fed on raw or on pasteurized milk. J. Y.

(*National Institute of Research in Dairying, Reading*)

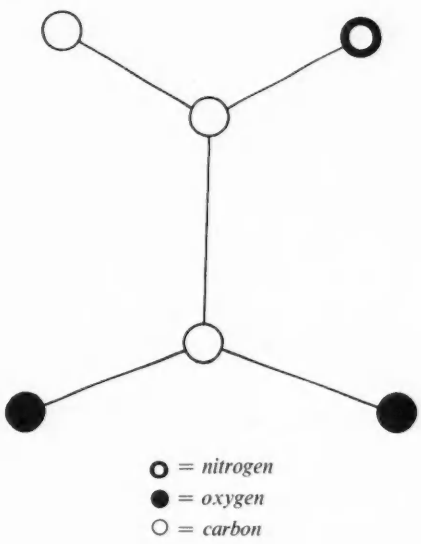
"UNBOILING" AN EGG

CAN a boiled egg be made raw again? Can it, so to speak, be unboiled? We think of a raw egg as a living thing; a boiled egg, on the other hand, is dead, and to make it alive again seems as impossible as inventing the *perpetuum mobile*. Yet something

closely approaching to unboiling an egg has been done by two American scientists, Anson and Mirsky. In order to describe their discovery, we have to begin by explaining in some detail the process of boiling an egg.

Let us consider the white of egg. When the egg is raw, this is a liquid which consists essentially of a substance called *albumin*. This substance can be isolated and, when dissolved in water, displays a number of properties which are characteristic of a *protein*. A pure solution of egg albumin contains only one kind of molecule of approximately spherical shape and of a weight in the neighbourhood of 40,000 times that of a hydrogen atom; the molecules themselves consist chiefly of amino-acids (see figure), linked together to form a three-dimensional structure about which we know as yet very little. The albumin can be crystallized and shows a phenomenon known as specificity: this means that egg albumin, say of the hen, not only distinguishes itself from all other proteins in the egg or in the body of the hen, but also that it is different from all albumins taken from eggs of different species of birds. If a solution of albumin is boiled, then the albumin is precipitated in the form of white flakes which constitute nothing else but boiled white of egg. The flakes dissolve in dilute acid. The solution of this boiled or *denatured* albumin, however, has properties which are totally different from the unboiled or *native* substance. The molecules have ceased to be spherical, nor are they all the same weight. The albumin can no longer be crystallized, and it has lost all specificity, i.e. it is not readily distinguishable from other denatured proteins.

Now let us suppose we have boiled a protein solution until all the protein is precipitated. How can we reverse the process? First we have to dissolve the protein by adding a small quantity of acid. If we would now add an equivalent amount of alkali to neutralize the acid, all the protein would be precipitated as before. If, instead of adding all the alkali at once, we carry out the neutralization in two steps, by first adding an amount of alkali which is only just insufficient to precipitate the protein and waiting for a few hours before adding the remainder, then only a small amount of protein will be precipitated and the rest will



remain in solution. Now the surprising fact is that the part of the protein which is found in solution has recovered all the properties of the original native protein.

In the native state, haemoglobin is able to act as an oxygen-carrier and pepsin and trypsin, two proteins of the alimentary canal, can digest other proteins. On boiling, the activity of these three substances is lost. If the native proteins are regenerated by reversal of the denaturation, then their original activity is completely restored. Similarly, reversal of the denaturation can be achieved in the cases of serum albumin, a protein of the blood, and of egg albumin, although in the latter case the percentage of the native protein which can be regenerated is rather small.

Since Anson and Mirsky made the discovery of reversible denaturation, they

have found that it has an important physiological function. *Visual purple* is a light-sensitive substance which is present in the retina and which the eye uses for seeing in dim light. It is a protein which is denatured by the action of light and regenerated by the reversion of denaturation in the dark. This is the reason why our eyes require some time to become accustomed to the dark after having been dazzled by a bright light.

M. F. P.

(*Anson and Mirsky, Rockefeller Institute for Medical Research, New York and Princeton, N.J.*)

VITAMIN K

THERE are many vitamins which are necessary for various species of animals but not for man. Until recently, it was thought that vitamin K, discovered by Dr Dam of Copenhagen in 1934, was needed only by young chicks. Dam had shown that baby chicks, fed on a diet containing all the then known vitamins, began to have severe haemorrhages. These haemorrhages could be prevented if extracts of cereal grains were added to the diet, and it was concluded that these extracts contained a new vitamin which was called vitamin K.

Since this discovery, rapid advances have been made in the study of this vitamin, and it now appears that it is just as important for humans as for chicks. It was found that one of the substances essential for blood clotting, known as prothrombin, was greatly reduced in the blood of deficient chicks. Then it was discovered that people suffering from certain forms of jaundice—"obstructive" jaundice—also had a very small amount of prothrombin in their blood. It has long been known that operations to remove the obstruction in these patients were rather risky because of the difficulty in stopping bleeding. The reason for this is now clear. The obstruction blocks the bile duct and prevents the bile reaching the intestine. The bile pigment is thus forced into the blood and causes the jaundice. The absence of the pigment from the intestine is not important, but other constituents of the bile, notably the bile salts, are important. They are concerned in helping the absorption of fats from the intestine into the blood. Now vitamin K itself is soluble only in fatty substances, and if the bile salts are not present in the intestine, it cannot be absorbed. This is the reason for the low prothrombin in the blood of patients with obstructive jaundice. If they receive vitamin K by injection, or the vitamin and bile salts by mouth, the prothrombin rises to normal values, and they can then be operated on without the danger of uncontrollable haemorrhage.

Dam now reports that many common diseases of new-born infants are probably due to lack of vitamin K. Soon after birth, it is quite common for infants to become jaundiced or anaemic or to begin to bleed. Most of these babies get better spontaneously, but sometimes they get rapidly worse and may die. Dam has found that the blood of these infants is deficient in prothrombin, and he has been able to cure several of them by giving them vitamin K.

So far, no cases of clear-cut deficiency of vitamin K in adults have been described. But Dr Kark and Dr Lozner of Boston, U.S.A., investigated four cases of other vitamin deficiencies—three of scurvy and one of pellagra—in which the patients had lived on very poor diets for some time. In

all four cases, the amount of prothrombin in the blood was very low, and the administration of vitamin K brought this up to normal. In these cases, haemorrhages due to the vitamin-K deficiency had not occured, but this was because the symptoms due to lack of the other vitamins showed themselves first. It does seem likely, though, that further investigation will show that a nutritional deficiency of vitamin K in adults may occur without necessarily being associated with lack of other vitamins.

J. Y. (*Kark and Lozner, Boston, U.S.A.*)

THE CARTESIAN DIVER AS A MANOMETER

GASTRULATION is a stage of crucial importance in embryonic development. It is in this stage that the neural tube, the main vertebrate axis, and other fundamental organs come into being. In the transformation of a blastula into a gastrula, one tiny piece of tissue commands the greatest scientific interest, namely, the so-called "dorsal lip of the blastopore", which, by exercising a stimulus on the neighbouring parts, induces the formation of the above-mentioned all-important organ. When implanted into other embryos, it induces the neural tube in places where normally it would never have been formed. The animals used for such experiments are mostly frogs, toads and newts.

Dr J. Needham and his collaborators have demonstrated that the stimulus exerted by the dorsal lip is, partly at least, of a chemical nature, and that even a petrol-ether extract has the magic power of evoking neural tubes. The active substance seems to be in all probability a sterol-like compound. Synthetic chemical substances, such as dimethyl-phenanthrene, are also capable of inducing a neural tube in parts of the embryo which are not normally destined to form it.

Exceedingly small quantities only are required for this purpose; amounts as small as 1×10^{-6} mg. per embryo are optimally active, so that the effect can be compared to that of hormones and vitamins.

Dr Needham has, further, deduced from his experiments and those of other workers that the active substance is not only present in the dorsal lip, but everywhere in the amphibian egg, though in a hidden condition. It has to be "liberated", e.g. by boiling to become active. Only in the dorsal lip is the substance normally liberated. Dr Needham is now trying to find out by what mechanism the hormone can be set free, but this presupposes an exact knowledge of the metabolism of the several portions of the gastrula. In view of the microscopic dimensions of the object, one might almost despair of solving this task. But, following a suggestion of Lindstrøm-Lang, Dr Needham has found the so-called "Philosophical Toy", the Cartesian Diver or "Devil", capable of measuring the gas exchange. In this ultra-micro-manometer, a change of 0·008 c.mm. in the gas volume is enough to alter the level by 1 cm. (as against 20 c.mm. required by the Warburg manometer).

The results seem to show that there is a difference in quality, not in quantity, between the metabolism of the dorsal lip, when invagination begins, and that of the ventral ectoderm. The oxygen consumption was equal in both parts. But anaerobic glycolysis and anaerobic ammonia production were three times as high in the dorsal lip as in the ventral ectoderm, and the respiratory quotient was different.

Dr Needham suggests that the primary organizer of the amphibian egg, that is, the hormone in question, exists in a masked form in combination with glycogen and protein, normally liberated and active only in the dorsal lip, but able to be liberated artificially in other parts.

G. R. (*Needham, Biochemical Laboratory, Cambridge*)

THE AGE OF ANIMALS

TREES are not the only organisms whose age can be told by counting their rings. It has long been known that the annual growth rings in the scales and otoliths of fishes may be used to determine their age, and now it is announced that a similar periodic structure can be seen in the hair of mammals. In this case, however, the unit of growth is not a year, but a day. Some hairs, particularly those of the "under-coat" of the duck-billed platypus, are known to have a ladder-like structure when viewed under the microscope. By dividing the total length of the hair by the average length of a "rung" in the ladder, a number is obtained which approximates very closely to the number of days which the animal has lived. In the hair of certain other species, such as the merino sheep, the periodic structure is not immediately apparent, but after treatment for a few hours with an alkaline solution, the hair is thrown into a beautifully regular series of waves. The length of each wave is in this instance about a sixtieth of an inch: this would allow six inches for a year's growth, which is in fact just the rate at which the hair grows. Some animals, for example the musk ox, are known to cast their under-coat each year, and for these an examination of the hair can clearly give no clue as to their age, but the merino sheep (in which the wool is entirely under-coat, the outer hair of the wild sheep having been lost) has on occasions been sheared of as much as five years' growth. Each fibre of this wool presumably bears in its structure a day-to-day history of the animal's life.

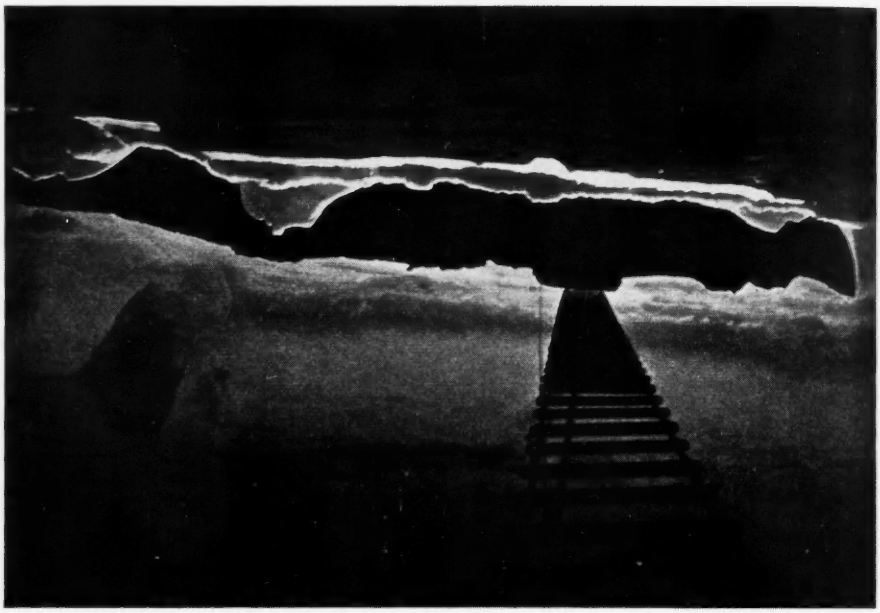
D. A. W.

(*Barker, Melbourne*)

RESEARCH AT HIGH ALTITUDES

AT the end of the last century permission was given to a Swiss company to construct a railway to the summit of the Jungfrau (14,000 ft.). It took more than ten years to complete the tunnel leading to the Jungfraujoch (11,000 ft.) at a cost of over £600,000, so that a continuation of the tunnel to the summit appeared impracticable. Although the erection of a scientific station on the Jungfraujoch had been one of the conditions the Swiss Government had made in permitting the building of the railway, it was not until 1928 that plans were completed and the necessary capital secured. The *International Research Station* was finally opened in 1931, after the majority of European governments and scientific academies had subscribed towards its endowment. It is built on an artificial platform hewn out of a steep rock

The International Research Station on the Jungfraujoch



Inside a Crevasse, looking vertically upwards. The ladder leads to the glacier surface, where the sun is seen shining through overhanging snow

face and is accessible only through a system of tunnels connecting it with the railway terminus and the glacier. The Research Station offers comfortable accommodation for about twenty people and, in addition to a library, contains laboratories for physical, chemical and physiological work.

What is the purpose of having a research laboratory at this altitude? This question can best be answered by giving a short account of some of the work which has been carried out at the Jungfraujoch since the Research Station came into being. Decisive advances which would have been impossible without its existence have been achieved in such divers subjects as physiology, physics, astronomy and glaciology.

In physiology the study of *mountain sickness* is of considerable importance owing to the bearing which it has on the general theory of respiration. The symptoms of mountain sickness include headache, shortness of breath, depression and, in severe cases, nausea and loss of consciousness. They are all directly attributable to lack of oxygen. Healthy individuals become acclimatized to the height and feel perfectly normal again after a few days. This acclimatization is achieved by a large increase in the number of red blood corpuscles and by deeper breathing. The precise mechanism of adaptation is of great interest and has been studied by physiologists working on the Jungfraujoch and accompanying Mount Everest expeditions.

Nearly all the physical investigations carried out at the Jungfraujoch are concerned with the study of radiations which reach the surface of the earth from outside and undergo alterations in the course of

their passage through the atmosphere. The Research Station has been most useful for the study of *cosmic rays*, a radiation of greater penetrating power than any hitherto known. At sea-level cosmic rays are known to occur in showers which are spread over large areas. It has been suspected that these showers are secondary phenomena produced by collisions between fast particles of cosmic origin with atoms in the atmosphere. Obviously one of the most important tests of this theory is the study of the variations of the properties of the showers at different altitudes.

It is generally known that the intensity of the ultra-violet radiation of the sun at high altitudes is greater than at sea-level. Astronomers make use of this fact for studying the *ultra-violet spectra* of celestial objects. An article in the February 1940 issue of this journal described how these spectra can tell us something about the temperature and the composition of the surface of a star. Another subject for astronomic research is the observation of *sun-spots*. At sea-level, the hot air rising from the surface of the earth produces disturbances in the atmosphere which cause images of sun-spots in the telescope to flicker, making their photographs blurred. The Jungfraujoch is mostly surrounded by snow; hence the heating of the atmosphere by the earth is negligible, and the apparent flickering of the sun-spots much reduced. It may perhaps be pointed out that sun-spot variations are not of purely academic interest, because they are intimately connected with terrestrial magnetic storms and consequent disturbances in wireless transmission.

Glaciology has always suffered from the difficult conditions under which scientists had to work, especially in arctic and antarctic regions. Using the Jungfraujoch as a basis, it has now become possible to bring much more powerful weapons to bear upon the problem. Most glaciological problems are connected with conditions in the interior of the glacier which can be reached by descending into crevasses (Fig. 2), by excavating artificial shafts or by drilling boreholes. In a recent expedition all these methods have been used extensively with the view of obtaining a picture of the density and temperature distribution in the glacier, and of elucidating the mechanism of glacier flow.

M. F. P. (*International Research Station, Jungfraujoch*)

TEETH AND HEALTH

No one can have failed to notice the large number of young people in this country who have false teeth. An extraordinary diversity of views—most of them very strongly held—are current as to the reasons for this. In the main, however, two questions remain to be answered. First, what are the causes of dental decay, and are they much more prevalent in England than, for example, in France? Secondly, is there a tendency in this country to extract teeth —perhaps unnecessarily—which abroad would be conserved? Two recently published papers contribute interesting data towards the solution of both these problems. Miller and Crombie at Newcastle examined the teeth of over 1800 elementary school-children between the ages of 10 and 14, and classified them into seven groups according to the state of their teeth. Only twenty-five were found to be completely free from caries. They selected twenty-five children from the group with extremely bad teeth (having an average of twelve carious

cavities) and compared the general health, diet and so on of these with the twenty-five children free from caries. They were thus able to determine several of the factors which were apparently responsible for the extreme difference in the state of the teeth in the two groups. One of the most interesting observations was that cleaning the teeth appeared to play no part in preserving their health. Twelve of the twenty-five children with perfect teeth had never used a tooth-brush, and four more had used one only at irregular intervals. The most important factor associated with bad teeth was the occurrence of severe illness—mastoid infection, pneumonia, etc.—or the early incidence of infectious fevers such as measles or whooping cough. The health of the mother during pregnancy also plays a part in determining the state of the teeth of the child—only one mother of the twenty-five children with perfect teeth, and as many as eleven of the mothers of the group with bad teeth, had been ill during the pregnancy. Another factor which seemed to be connected with bad teeth was malnutrition in infancy—fewer of the group with bad teeth were breast-fed, or given orange juice or cod-liver oil, than in the group with perfect teeth. There were more first-born children in the caries-free group than in the group with bad teeth; that is, later children tend to have less healthy teeth than their older brothers and sisters. This may be due either to the depletion of the calcium stores of the mother due to repeated pregnancies or to the less favourable economic position in families with more or less fixed incomes when there are more children. The effect of a favourable environment and good nutrition was well shown by a comparison of the teeth of 115 children of the same age in a children's home with the 1800 elementary school-children. 28% of the former had perfect teeth, whereas only 1·3% of the latter were completely free from caries. To summarize then, good teeth are more likely to be found in well-nourished, healthy children of healthy mothers. The use of a tooth-brush may be aesthetically pleasing, just as washing the face, but neither appears to contribute appreciably to the state of health.

With regard to the question of possible unnecessary removal of teeth, the investigations of Vaizey and Clark-Kennedy at the London Hospital suggest that there is indeed this tendency towards excessive extraction in this country. About a century ago, it was suggested that infected teeth might be responsible for various diseases, particularly rheumatism and various types of dyspepsia. Particularly during the last 25 years, it has been common in England and the United States of America to examine carefully—using X-rays if necessary—the mouths of patients suffering from these diseases and to remove all teeth suspected of infection. Vaizey and Clark-Kennedy, impressed by the large number of patients coming to them after such extractions, complaining of no improvement or even of aggravation of their symptoms, conducted a careful examination of 234 patients who had had dental extractions for various reasons. The extractions in 126 of these were for purely dental reasons, and although quite free from these symptoms before the extractions, thirty-nine of them developed dyspepsia and nineteen developed rheumatism after the removal of their teeth.

Of the 234 patients investigated, thirteen with rheumatism had had their teeth taken out because it was supposed that dental sepsis was responsible for their condition. Five of these had benefited. Of these patients, 76 had suffered from dyspepsia and, dental sepsis again being held responsible for their symptoms, had had their teeth extracted. Only six of these, however, were improved by this treatment. The fact that in fifteen of these cases the symptoms were actually aggravated after extraction, together with the large number of cases developing dyspepsia for the first time after dental extraction, led Vaizey and Clark-Kennedy to stress the importance of the mechanical factor. If several teeth are to be removed, the patients themselves frequently

prefer, for reasons of economy, to have all their teeth extracted. They feel that a partial denture will sooner or later have to be replaced by a complete denture when the remaining teeth decay. This means that often teeth which might have been retained and might have had some function in chewing food are dispensed with unnecessarily. Moreover, the majority of hospital-class patients cannot afford temporary dentures, and consequently several months elapse with no teeth at all before they can have permanent dentures fitted. Frequently, too, the dentures are not fitted very well, and Vaizey and Clark-Kennedy say they often meet patients who take out their false teeth when they eat a meal! It is clear then that dyspepsia may readily be brought on by inefficient mastication in the mouth following the removal of the teeth.

Thus, dental infection as a cause of rheumatism or of dyspepsia has not been proved. Both can occur in patients who are completely edentulous, and, in addition, the treatment of these conditions by extraction very frequently produces no benefit and in fact may aggravate the symptoms. The conclusion drawn by Vaizey and Clark-Kennedy is that teeth should be dealt with entirely on their own merits, regardless of the presence of dyspeptic or rheumatic symptoms. From the point of view of preventing the onset or the aggravation of indigestion, everything possible should be done to preserve the natural teeth. If extraction cannot be avoided, efficient dentures should be fitted as soon as possible.

J. Y.

(*Miller and Crombie, Newcastle. Vaizey and Clark-Kennedy, London*)

Animals and Music

NEITHER music nor the appreciation of it is peculiar to mankind. Response to music is found in many different groups of animals.

Among mammals, it would seem that the rhinoceros is an exception; but seals and sea-lions, while quite indifferent as to whether the classics or "swing" is played to them, are apparently entranced by music, and will remain with eyes closed, half out of the water, until the melody dies away. Indeed, seal-hunters once used to lure the animals within range by playing to them. It is well known that wolves, jackals, and other carnivores are responsive to music, although only the cheetah is actually attracted. Minor chords always seem to produce depression in carnivores. In spite of the jests that are well known, it is certain that cows really do appreciate music; there are authentic stories of cows waiting spellbound while listening to wireless sets or gramophones belonging to campers. It has even been stated that music in milking-sheds increases the output of milk, and some old pictures show musicians playing while milking is in progress—"Milk from contented cows."

Music has little effect on reptiles. Young crocodiles, however, always remain with their heads above the water while music is being played. Snakes, on the other hand, contrary to the accepted belief, are quite insensitive to music of any kind.

Some Amphibia are affected by it, and there are many reports of newts which have swayed their bodies as though beating time to music.

Sound-appreciation in fish is still the occasion of experiment and debate. Fish have sometimes been taught to connect the sound of a buzzer with feeding; certain

gurnards have been heard by fishermen to make "grunting" noises, so it would seem that they must be able to hear.

Among the Arthropoda, spiders and insects are most responsive. Some spiders have often been made to come out from their hiding-places by music.

Many insects have various kinds of auditory organs, particularly those which stridulate, such as locusts and grasshoppers. The "ears" or tympani are borne either upon the legs or upon the body. Some interesting and rather amusing experiments have been made with crickets: it was thought that males, by not chirping at exactly the same instant, but alternately, did not interfere with one another's efforts to attract the females, and this was proved by suspending male crickets in vessels hung from small gas-filled balloons, so that no conflicting stimuli could interfere with their reactions. The note made by mosquitoes is thought to be produced by forcing air through the proboscis. No special tympanal organs are present, but probably, as with other insects, sounds are perceived by special minute sensory hairs. Thus mosquitoes respond to the note of a dynamo if this happens to be of the right pitch. It has been found possible to electrocute large numbers of the little pests in this way.

Some moths produce sounds, such as the well-known squeaking of the death's-head (*Acherontia atropos*). This sound is also supposed to be made by the forcing of air through the mouth parts. Here again, although tympanal organs are found in Lepidoptera, their functions are obscure, and it is probable that sensory hairs are the receptors. Sound, in insects, is always rather more "felt" than heard. The sound of the cicada, which has been mentioned in the classics (as in Virgil's *Georgics*), is produced by the vibration of a tightly stretched membrane. Some species of cicada in Australasia, which live high up in trees, are only known by the characteristic notes they produce.

Stridulation is not confined to well-known insects like grasshoppers. A family of wingless solitary wasps (Mutillidae) stridulate by rapidly telescoping the abdominal segments in and out when they are handled, thus making a harsh creaking sound. The larvae of the common wasps, *Vespa germanica* and *V. vulgaris*, have been observed to react to high-pitched noises simulating the buzzing of the wings of worker wasps; they "bow" to and fro, and this is thought to be correlated with the return of worker wasps with food for the larvae.

R. DAVIS

READERS of *Discovery* will remember that the 1939 September issue contained a note on the nature and significance of the Saxon ship-burial recently excavated at Sutton Hoo, Suffolk. At that time the examination of the objects discovered was only in its preliminary stages. Volume XIII: No. 4, of the *British Museum Quarterly*, published in December 1939, is devoted to a full description and discussion of the find. The account is divided into six sections, dealing in detail with the discovery of the finds, the gold ornaments, the silver, the coins, other finds, and the archaeological significance of the Sutton Hoo discoveries. There are eleven large plates, which show both the elaborate ornamentation of the objects and the excellent state in which many of them have been preserved. The *British Museum Quarterly* is published by the Trustees of the British Museum.

BEE VENOM & RHEUMATISM

By C. H. MARCH

THE theory that bee venom is good for treating rheumatism is not new; it dates back to prehistoric times, when the venom of all creatures was held to have some therapeutic value, and the venom of snakes, bees, and hornets, and the poisonous skin secretions of toads were regularly prescribed for various ailments. The first records of the use of bee venom for the treatment of diseases were left by the ancient Egyptians, and in the Middle Ages the bee was held to be a valuable therapeutic agent. The witches' chant in Shakespeare's *Macbeth* reminds us of the value placed on the organs of various animals not only for their therapeutic qualities but also for their usefulness for more nefarious purposes. Two or more centuries ago the peoples of Europe had a saying that if you had rheumatism and were stung by bees your rheumatism would go, and the medical literature of the nineteenth century contains references by many noted European doctors to the efficacy of the venom of bees in treating rheumatism. The statistics regarding rheumatism in bee keepers are interesting. In Europe it has been found that bee keepers rarely suffer from the disease, and of bee keepers who had rheumatism before keeping bees 58 per cent were completely cured, and 29 per cent were very much improved.

The modern use of this treatment was initiated in the eighties of the last century

Persuading the bees to sting through a thin membrane

The old method of bee venom therapy: letting the bee sting the arm

by Dr Terc, of Marburg, in Yugoslavia, and Dr Keiter, of Graz, in Austria. Dr Keiter had his own private sanatorium complete with bees. His patients were turned out in his grounds once or twice a day and were regularly stung by the swarms of bees kept there. This sounds a rather painful process, and some people would no doubt prefer the rheumatism. Nevertheless, Dr Keiter obtained very good results, though his patients may have decided to "stay cured" rather than risk the bees again. The next step was taken when a continental doctor managed to make solutions or extracts of the bees' venom and to inject it in gradually increasing doses into the patients' arms. This gave good results but was also inclined to be rather painful. Then Dr Foerster, a professor of the University of Wurzburg, hit upon the idea of combining the venom with an oily substance so that it could be used as a salve and rubbed on the affected part. This salve contains a number of small crystals of venom which make small scratches on the skin and so facilitate absorption; once in the system, the venom can exert its beneficial effect throughout the whole body. So far bee venom salve has been found useful in the treatment of rheumatism of the muscles and of the joints and in the treatment of neuralgia, sciatica and lumbago.

When a substance such as bee venom is used extensively, there must be some way of obtaining regular supplies. In Germany there is a bee farm used entirely for this purpose. The bees are housed in long rows of wooden hives, and each day girls, in special suits with veils and gloves to protect them from stings, catch them and extract their venom. Various ways of doing this have been devised. The original method was to kill the bee and then to remove the sting and the venom bladder and extract the venom from them, but with this method the venom became soiled during extraction. Another way was tried in which the bees were anaesthetized with

The new, painless method of bee therapy: rubbing on a bee venom salve

ether. Bees in the excitation stage of ether anaesthesia are known to spout out their venom, but as they also empty out their honey, their stomachs, and their mud glands, this method again gives soiled venom. The method now used is to catch each single bee and make it sting through a thin membrane either into an empty jar or into a physiological solution of salt in water.

All sorts of problems had to be worked out at the farm. For example, no one knew how old a bee had to become before it had any venom, whether bees had the same amount of venom each season in the year, or whether different sorts of food caused any variation in the amount of venom. Investigation showed that newly born bees had no venom at all, but that production began during the first or second day after birth and increased up to the fifteenth day. After this, production declined, and finally the bee produced no more, but all the venom it had already produced was retained in its venom bladder. The life of a normal bee is only three to five weeks, and if it stings into human or animal skin, the sting remains there and the bee will die within a few hours. If it stings into a thin membrane, however, it may be "milked" of its venom several times. The first generations of bees in the spring usually have the most venom, and the venom content of succeeding generations decreases until autumn, when it begins to rise again. Workers at the bee farm found that the venom contains a large amount of albumen, and that if bees are fed on food free from albumen they produce practically no venom.

The collections of venom from different bees are combined to form a standardized product, so that a doctor prescribing treatment with bee venom salve for his patient's rheumatism will know that each time he uses it the salve contains the same amount of active bee venom.

The author is indebted to Messrs Coates and Cooper, of London, for information and photographs.

Rows of hives in which the bees are kept

Workers at the bee farm on their way to the hives

HOW OLD IS THE EARTH?

Geological time is divided into periods in much the same way that English history is divided into the reigns of kings. The "reigns" in geology are the periods during which certain species of animals or plants were in existence on the earth. In this article, Mr Arthur Bray, of the Mining and Technical College at Wigan, shows us how, by subdividing these periods, we can reckon the speed of evolution.

"MILLIONS of years ago" is a phrase which used to be typically associated with geological statements, but a good deal of this naïve approximation is now receding before the accurate physico-chemical measurements of modern science.

As recently as twenty-five years ago, methods of calculating geological time were in a very unsatisfactory state, and different methods yielded distressingly divergent results. Methods using the salinity of the oceans suggested about a hundred million years for the age of the earth, but this method is very unreliable, as, among other things, there may be a base exchange of sodium with the sediments accumulating in the oceans, and sodium may be acquired from sources other than the denudation of land areas. Estimates of the rate of sedimentation may be reliable in a few isolated cases covering relatively small periods of time, as in the examples of the Swedish rhythmic sedimentation varves or annual laminae of clay.

On the other hand, radioactive minerals change to isotopes of lead with the production of helium, and the rate of production of each of these from the parent substances is known. Uranium, actino-uranium, and thorium are the chief radioactive minerals, and these are present in most rocks, especially in the geologically older ones. In igneous rocks the amount of radium varies from $0{\cdot}36 \times 10^{-12}$ to $4{\cdot}78 \times 10^{-12}$ gram per gram of material, the average being about $1{\cdot}7 \times 10^{-12}$ gram. Granites contain much more radium than basalts. Sedimentary rocks are much less radioactive than the igneous rocks, and average about $1{\cdot}1 \times 10^{-12}$ gram per gram of rock. Granites contain about 2×10^{-5} gram of thorium, and basalts about $0{\cdot}77 \times 10^{-5}$ gram per gram of rock.

The rate of change of radioactive substances to helium and lead isotopes has probably not altered during geological time. Heat and pressure do not affect the rate, a fact which is borne out by observations on pleochroic haloes in minerals such as mica.

The amount of radioactive substance in a rock and its associated helium and isotopes of lead can be measured. Estimates of the age of a rock or mineral based on measurements of the contained helium agree very closely with those based on the lead isotope ratios. For minerals containing both thorium and uranium the age in millions of years is given by the formula $\frac{\text{Pb}}{\text{U}+0{\cdot}36\,\text{Th}} \times 7600$, or if the helium content is used, by the formula $\frac{\text{He}}{\text{U}+0{\cdot}27\,\text{Th}} \times 7600$ million years. A correction for the complication introduced by the presence of actinium and the wearing-out of the parent elements has to be allowed for. If the amount of helium is given in cubic centimetres per hundred grams of rock or mineral, the age is given in millions of years, by multiplying the helium ratio by 8·8. If thorium is absent, the age of the rock is given by the formula $\frac{\text{Pb}}{\text{U}} \times 7600$ million years, with the above corrections. The

presence of any original lead must be allowed for. One of the oldest minerals examined was found to be 1700 million years of age, whilst the analysis of some meteorites gave an age of 2800 million years. The age of the earth from the time of solidification is probably not less than 1900 millions of years.

By means of these measurements, the geological divisions of time can be given a definite meaning and time value. They are found to cover different lengths of time. The pre-Cambrian Era itself extended to over 1000 million years. The following era, known as the Lower Palaeozoic, covered 175 million years and is divided into three distinct periods, viz. the Cambrian Period occupying about 90 million years, the Ordovician about 60 million, and, at the top, the Silurian Period of only 25 million years. The Upper Palaeozoic Era again covered about 150 million years and is also divided into three periods, the Devonian of 40 million, the Carboniferous Period 60 million, and the Permian Period of 40 million years. The Mesozoic Era was not so long, taking up only 90 million years. This era is also subdivided into three periods, the Triassic being 25 million years long, the Jurassic the same length, and the Cretaceous Period 60 million years long. The Tertiary Era was about 60 million years long.

* * *

The fact that it is possible to give the age of rocks and minerals with some degree of accuracy provides a means of solving geological problems. From the helium ratios of the rock known as Kimberlite which contains diamonds and fills the diamond pipes of South Africa, the age has been estimated by Holmes and Paneth at 58 million years, which gives a probable late Cretaceous age for the pipes. Enclosed in the Kimberlite are fragments of another type of rock whose helium ratios indicate a Cambrian age, whilst other fragments in the Kimberlite show a still greater age. Thus the rock fragments enclosed in the Kimberlite which filled the pipes were not derived from the same molten magma as that from which the Kimberlite was formed, but were picked up during the process of intrusion.

* * *

Before the discovery that rocks could be dated by measurement of the end-products of radioactive changes contained within the rock, geologists had to rely entirely on the evolutionary stages of certain groups of fossil plants and animals. Thus the period of time when the reptiles were the most prominent group of animals populating the world is termed the Mesozoic Era. The age of mammals is the Tertiary Era. Some idea of the speed of evolution can be obtained from the ages of rocks obtained from the helium and lead ratios. It took about 85 million years from the inception of the graptolites to their extinction. The ammonites, those coiled fossils so common in the cliffs at Whitby and Lyme Regis, lasted about 110 million years. The earth was at least 1175 million years old before the true fishes were evolved from earlier ancestors, and had a further 106 million years to go before the reptiles became dominant. The first mammals came in during the Cretaceous Period after at least 1420 million years of earth history. The man-like apes are a mere 25 million or so years old, and the modern flowering plants about 145 million years.

Geological time is divided into periods in much the same way that English history is divided into the reigns of kings, such as the Victorian Era. The "reigns" in geology are the periods during which certain species of animals or plants were in existence on the earth. These periods can be further subdivided in great detail, just as the period of the Hanoverian Dynasty can be split up into the reigns of the Georges. Thus the Mesozoic Era, as stated above, was the period when reptiles and ammonites were the dominant groups of animals on the

earth. This era can, however, be more minutely subdivided using the more lowly but more rapidly evolving groups of animals as indicators.

The speed of evolution varies considerably in different groups. The horny shelled brachiopod *Lingula* survived almost unchanged from the Cambrian Period down to the present day, i.e. for at least 500 million years. On the other hand, the group of graptolites known as the monograptids were first evolved at the beginning of the Silurian Period and became extinct at the end of that period in about 25 million years. There are about twenty-three zonal species of monograptids, one species succeeding another in time. One zonal species may not have evolved directly from the preceding zone graptolite, but they are always found in the same relative order throughout the Silurian rocks of the world. On this basis, and assuming an equal length of time from the inception of each species to its extinction, the species life of a *Monograptus* was about one million years. Individual species of ammonites probably had the same period of existence.

* * *

The only species of value for the small-scale subdivision of time are those which were evolving rapidly, had a sudden inception, and on finding themselves eminently suited to their surroundings, spread with amazing rapidity over the face of the earth. With such specialization, however, they were unable to face up to slight changes of conditions, and as rapidly died out and became extinct. Once extinct, a species never reappears. Were it not so, the whole of geological chronology would fall to the ground. The production of new species seems to occur in spurts, and is especially characteristic when a race is dying out. The race seems to be experimenting as to the type which shall succeed it. The unsuccessful experiments rapidly die out, and it is these which are of such value in the biological subdivision of time. The successful experiments live too long. The period of time during which a fossil species was in existence forms a unit of geological time which is almost constant over the whole world. The events taking place during this unit period can be studied and put together to give a picture of the geography during that period of time. Thus whilst Britain was "enjoying" a desert climate during the Permian Period, the southern hemisphere was in the throes of an ice age which left a fossil boulder clay over great areas of country.

Each group of rocks is being intensively studied and still further subdivided, using the contained organic remains as a time scale, until now each era and system is divided into scores of hemera or time units, each identified and named after the species of animal or plant typical of that time.

* * *

In certain areas such as Scandinavia and north Canada, glacier lakes have existed, and into them the melt waters of the glaciers have carried fine muds mixed with material consisting of coarser grains. In the comparatively tranquil waters of these freshwater lakes, there is a differential settling of the fine sediment. The coarser grains reach the bottom first during the melting period of the ice. The bulk of the finer mud would settle later during the winter months, and the finest particles of all would settle last. Thus in each season of sedimentation the lowest formed layers would be the coarsest grained, grading upwards with increasing fineness to the finest textured mud at the top. The formation of one layer will take place each season, and in a lake there may be accumulated great thicknesses of clays which show banding or layering, the layers or varves being thickest when the summer melting period was longest, and the thinner varves indicating a short cold summer. The relative thickness of each varve will therefore give some idea of the climate of the period during which it was forming, and

the counting of the varves will give the time in years in the same way that the annual rings of trees are used. In Scandinavia these banded clays have been extensively used for the subdivision of late glacial and post-glacial time. The varves of north Europe extend back nearly to the last ice age. They may be in process of formation at the present time in the Gulf of Bothnia, and may go back for 35,000 years.

Features perhaps paralleling to some extent the Swedish varves are the graded beds of the Palaeozoic strata. The graded beds are strata about 2 or 3 ft. thick, the lower portion of which is coarse-grained and sandy, grading upwards into finer sand intermixed with shaly material towards the top of the stratum. Beds of rock such as these may be repeated through great thickness of deposits. Their time value may be from 50 to 200 years.

Letters from Readers

"Think of a Number"

In a letter in your February number Mr A. Wohlgemuth criticizes Freud's experiment in which a number, thought of at random, is shown to have been determined by unconscious causes. The substance of the criticism is that associations can be called up by any number, even if such number has been produced from outside the subject's mind. This is a fact which no psycho-analyst would deny. The two statements, "any number I think of is determined by my unconscious" and "my unconscious will produce associations to any number with which I am presented", are not logically inconsistent, nor do they involve slipshod or unscientific thought, as Mr Wohlgemuth seems to think.

Freud maintains that determinism holds in the region of the mind. It follows that if I think of a number, apparently at random, that number must be determined; that is, it is arrived at in a different way from that by which the number produced by a roulette wheel or a dice is arrived at. If I am presented with a number, from outside my mind, my mind, in taking cognizance of the number, must think about it, and, if Freud is right, must think about it deterministically. This involves the same kind of process as before; that is, my unconscious will attach associations to the number and thus weave it into the pattern of my thought.

If mental activity is not deterministic, it must presumably operate according to the laws of pure chance, in which case it is difficult to understand how we are able to say "such and such an action is characteristic of my friend *X*". One of the best criteria of the scientific value of Freud's work is that such a large number of people have repeated his observations and confirmed his conclusions.

ROGER NORTH, King's Lynn.

Ultra Perception

I have read with great interest the article "The Ultra Perceptive Faculty", which appears in the December 1939 issue of *Discovery*, and it occurs to me that there are one or two points of interest arising from it, though these may have been considered by you and excluded for the purposes of compression into the present article.

Your suggestion of the possible application of the subject to psycho-analysis is interesting, and surely also the latter would be of value in controlling the experiments. There is a possibility that, if the subjects of the experiments were all people who had been successfully psycho-analysed, the percentage of positive results would be much higher.

For example, suppose that an unanalysed subject had, as a small child, been frightened of a tiger-skin rug and that *Encyclopaedia Britannica*, in its own book case, immediately faced the door in the room containing the rug, then, if during the experiment, the subject turns up the advertisement for that work, his first reaction will be "fear of tiger" or "tiger round corner", but this, even if it reached the conscious level, would be instantly suppressed and, thereby, *forgotten*. But this reaction of fear would be the one most likely to reach the sensitive and would be classified as wrong by the subject. Owing to the mechanism of suppression, the more strong the original reaction the more violent the denial.

But there is another side to this picture. It appears from the published results that the successful results largely show transmission of emotion rather than reason. The more successful an analysis the more emotion is removed from everyday life, and possibly, therefore, the fewer the contacts between subject and sensitive. Only experiment can show whether this is so or not, and whether after analysis the same people might not be able to train themselves to make ultra-perceptive contact in a more controlled way.

This raises the question whether there are people who "transmit" more strongly than others. Possibly your results will already show that more positive results were obtained with some subjects than others. If not, it might be a line to be followed up.

Another point arises out of your comment, on p. 659, para. 6, that when the subject is looking at a photograph of a fire, the perception of the sensitive is of the fire. A similar fact was observed by Mr J. W. Dunne, and recorded in his *An Experiment with Time*. The prevision of important events, about which he later read in the paper, was of the events themselves and not of the newspaper page on which they were described. This seems to be natural, as emotion and thought are concentrated on the happening and not on the paper and arrangement of black marks by which it is described. Most people, except mathematicians, think pictorially. Moreover, if, as suggested above, the emotion rather than the reason is transmitted, this result would be expected, since the emotion would almost always be attached to the happening and not to the photo or description.

I hope that these small points may be of some value in suggesting further extension of this line of research. Your action in applying sound mathematical principles and the theory of probability to so-called "super-natural" phenomena seems to me of the utmost value, for it will eventually force people to examine these matters objectively in an endeavour to discover the laws governing phenomena, once these have been proved to exist.

OLIVER H. MYERS, London, N.W. 1.

We sent this letter to Dr John Hettinger, whose reply is given here.

REGARDING the first point you raise, illustrated by the example of a small child "frightened of a tiger-skin", I wish to make it quite clear that, for the time being, I am refraining from advancing any theory as to what actually happens in the exercise of the ultra-perceptive faculty. What I mainly had in mind as regards psycho-analysis (see the penultimate paragraph of my article) was the *possibility* that some items might be given by the sensitive at a certain time, which, compared with the observation of the psycho-analyst at exactly the same time, *may reveal some relationship which would*

provide a useful clue in the first stages of his investigation of the patient.

I do not wish to deny that experiments with a number of people who had successfully completed psycho-analytical treatment may not be very valuable. However, from a practical point of view, as soon as I realized that the psychological make-up of the subject at the time of the test—including both the conscious and the subconscious—was probably the source of supply of the ultra-perceptive cognition, it occurred to me that the simultaneous use of psycho-analysis and ultra-perceptive reaction of a sensitive might prove a valuable accessory as regards the finding of clues a psycho-analyst is searching for in the first stages of his work.

What you say with respect to "emotion" and "reason" may ultimately prove to be true. After the first series of experiments, I myself came to the conclusion that "feelings and emotions" constituted the controlling factor, but, as the experiments advanced, I began to realize that it was too early to come to any conclusion in this respect. And for the time being I must leave it at that.

You are quite right in referring to the possibility that some subjects may show better results than others. The quantitative analysis which I have made in this respect shows clearly that this is the case. It may, however, be of interest to point out that some of the subjects, who gave *very poor* results in the general experiments, gave *very good* results with the "illustrated papers". Again, I do not wish to advance any explanation of this fact, but I am inclined to think that, so far as this specific observation is concerned, it is not so much a question of better or poorer "transmission", as of more *reliable identification* of the items given by the sensitive, the annotated "illustrated paper" being decidedly more reliable than "memory".

Referring to the last point in your letter, as regards the example of the burning pavilion at Blackpool, subject to what I said above about "feelings and emotions", I am inclined to take the same view as yourself, although it is too early to draw a general conclusion. Further research may show some differentiation between different types of minds.

J. HETTINGER, Streatham, S.W. 16.

"I WRITE this in London, waiting to be bombed, but refusing to believe that even if Western Europe is seriously damaged, this will spell the end of civilisation, or prove the danger of scientific knowledge. On the contrary, I believe that we need more science, not less, and science applied not only to certain branches of production, destruction, and medicine, but to human life as a whole. In this firm conviction I dedicate this book to readers who know enough history to realise that history is a record of pretty nasty facts, and that, in spite of this, human culture, including science, has advanced and will continue to advance."

J. B. S. HALDANE, from the Preface to *Keeping Cool.*

The Swimming of Scallops

By Professor C. M. Yonge

THERE are certain animals which we associate naturally with speed, and others, just as readily, with a more sluggish mode of life. Among the latter we should certainly include the bivalve shellfish, such as the oyster, the mussel and the cockle. Actually, of these three very typical representatives of this group of animals, the first is permanently cemented throughout adult life, the second is attached by means of stout threads known as the byssus, while the last, although more than usually active for a bivalve, can do no more than make ungainly lurches over and through the sand in which it normally lies buried.

We should certainly never expect to find in such a group of animals, encumbered as they all are with a heavy shell which is the necessary protection for animals lacking any other means of defence, any species which can swim. It is therefore with more than usual interest that we examine the movements of the scallop, one of the few bivalves capable of swimming.

The scallop shell is familiar to many who have no acquaintance with its owner in life. It is among the most beautiful of all bivalve shells in form, and is often beautifully coloured. It is not infrequent at the dinner table, while few natural objects have been more widely used as a design from the very earliest times, the ornamental edging known as scalloping being universally employed. Scallops are widespread; different species are found in cold and in warm seas, in shallow water and in deep.

The habits of scallops vary. Some are attached in the same manner as mussels, but many, including the commonest species around our coasts, are free-living and capable of swimming for some distance. From time to time the animals, which are some 2½ in. in diameter, begin vigorously to flap their shell valves, leaving the bottom and swimming upwards in a series of convulsive jerks, corresponding to the actual closures of the shell, and falling back a little between each movement. They swim with the free edge of the shell foremost and appear to progress by taking a series of bites out of the water through which they pass. The flat shell is almost horizontal, with the hinder, hinge region a little depressed. The shell is streamlined and so offers little resistance to passage through the water in the plane of the swimming movement. At the same time the flat under-surface prevents the animal from sinking down too rapidly between each contraction of the shell valves.

This swimming movement is not the only action of which the scallop is capable. If an animal which is lying quietly on the bottom is approached by an enemy or in any way startled, it carries out what is termed an escape movement. By a sudden closure of the shell, water is violently expelled from between the valves and the animal makes a sudden backward movement with the hinge foremost. Some scallops can also spin round on the central axis, while if placed upside down, although they normally lie on the right side, they invariably turn over.

The motive power for all of these movements is provided by the expulsion of water from within the shell, the animal consequently moving in the opposite direction. But it is clear from the various movements that can be executed that the animal is capable of controlling the direction in which water is ejected from within the shell. The mechanism for this consists of a curtain of tissue which hangs down from the

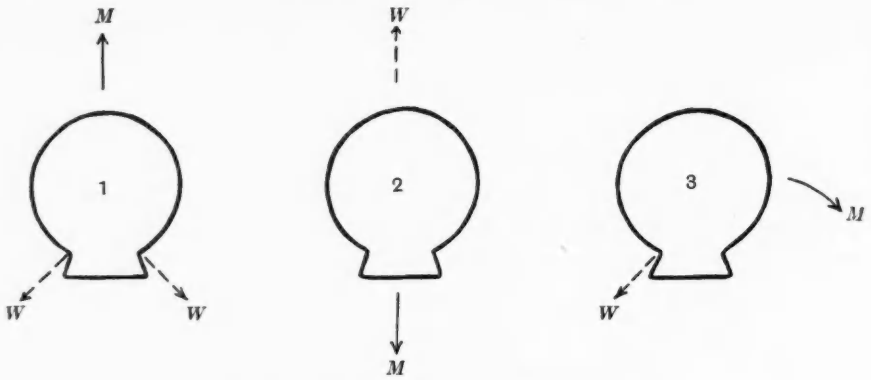


Fig. 1. *Swimming movement seen from above.*

Fig. 2. *Escape movement seen from above.*

Fig. 3. *Twisting movement.*

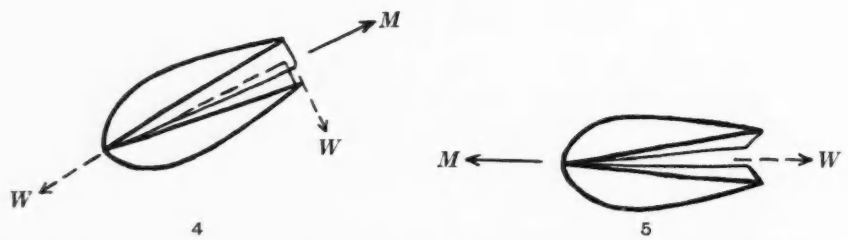


Fig. 4. *Swimming movement seen from the side, showing the arrangement of the curtains.*

Fig. 5. *Escape movement seen from the side.*

M, *direction of movement.*
W, *direction in which water is expelled.*

upper half of the shell and a similar curtain which projects upwards from the lower half. These can be extended or withdrawn locally according to the needs of the moment.

When the scallop is swimming, the curtains are extended around the free edges of the shell valves but withdrawn on either side of the hinge. The result is that water is expelled diagonally backwards on either side of the hinge and the animal thus moves with the hinge behind. The action of gravity is counteracted by a certain downward extrusion of the water from the side opposite to the hinge. This is brought about by the animal adjusting the upper curtain in this region outside the lower one. In the twisting movement, which is executed when the animal is lying on the bottom, water is expelled from one side of the hinge only, the animal swivelling round in a clockwise or anticlockwise direction according to which of the two sides it happens to be.

During the escape movement these lateral openings are closed, but the curtains are drawn back round the free edge of the

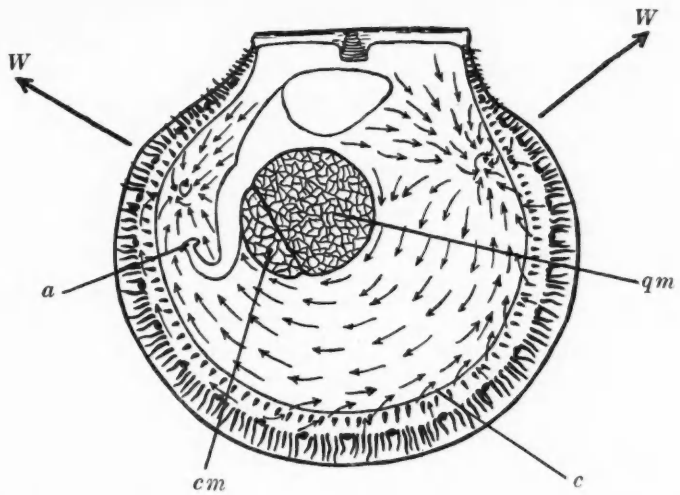


Fig. 6. Left shell valve of scallop, showing the currents for removing the sediment brought in with the feeding current, and also the centrally placed muscle. Most of the tissues have been removed. Arrows indicate the direction of the currents within the shell. a, *anus;* c, *curtain;* cm, *"catch" muscle;* qm, *large "quick" muscle responsible for swimming movements and ejection of sediment;* W, *direction in which water containing sediment is expelled.* (*Modified after Kellogg.*)

shell. Water is thus expelled violently in this direction and the animal consequently moves with the hinge in front. The turning movement is a little more complicated. The upper curtain around the free edge of the shell is adjusted outside the inner one so that water is ejected downwards in this region. At the same time water is expelled backwards on either side of the hinge. The combined effect of these two movements is to cause the animal to turn over on the hinge.

The energy for all of these movements is provided by the contraction of the thick muscle which runs from one half of the shell to the other. This muscle consists of two parts, one of which is known as the "catch" muscle and the other as the "quick" muscle. The former has the power of contracting for long periods and so holding the two halves of the shell firmly together. This is a protective device of the greatest importance in the life of scallops and of all other bivalve shellfish. The "quick" muscle, on the other hand, is capable of making repeated sudden contractions, each one of very short duration. It is this part of the muscle which is used in the swimming and other movements. It

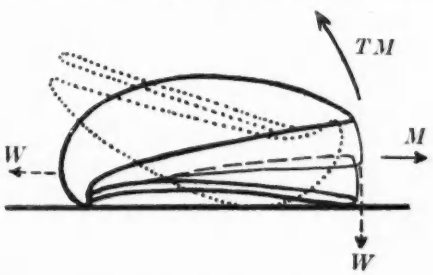


Fig. 7. Diagram showing the mechanism of the turning movement, final position of the scallop being shown by dotted outline. M, *forward movement;* TM, *turning movement;* W, *directions in which water is expelled.* (*Modified after Buddenbrock.*)

produces the necessarily sudden spurt of water from between the two halves of the shell.

The whole apparatus of shell, curtains and muscle thus provides a very ingenious mechanism for swimming. This immediately raises the question: How and by what stages was all this evolved? How did these originally sluggish, bottom-living animals acquire the power of raising themselves into the water above and moving through it in this entirely original manner? And the answer seems to be that it really represents no more than an apparently incidental development of mechanisms originally concerned with quite another problem.

All the bivalve shellfish feed by drawing within the shell a continuous stream of water. This passes through the extensive lattice-work of the gills which behave as an animated sieve. All the minute particles in the water are caught in the surface of this and carried to the mouth. Many of these consist of microscopic plants which occur in countless numbers in the sea and which constitute the food of all bivalves. But this method of feeding, admirably designed as it certainly is and as the vast abundance of these animals testifies, has its dangers. If there is much sediment in the water, this enters with the water current created by the animals and collects within the shell. If it enters in too great amount, the whole feeding mechanism becomes clogged and the animal is in grave danger. Indeed, any great disturbance in the water, for instance, a sudden storm causing the sand or mud of the bottom to be carried up in suspension, causes widespread havoc amongst bivalves.

To counteract this danger, they all possess the means of ridding themselves of excess material which collects within the shell. The "quick" muscle is certainly associated with this; it enables them to make sudden contractions which will drive out this material. The curtains serve to control the amount of water that enters, reducing the current if this carries too much sediment, allowing, by their withdrawal, more water to enter if this is clear.

In the scallops the quick muscle and the curtain are certainly better developed than in bivalves which do not swim, but it is a relative and not an absolute difference. The streamlined shell is certainly not concerned in the first place with any other function, but it is impossible to consider that this was, as it were, evolved so that the animal could swim. The most reasonable explanation would seem to be that, when the scallops acquired a shell of this character, the previous possession of the quick muscle and of the curtains made swimming possible. Then, with the passage of time, further development of these enabled them to exploit this new power of movement with greater and greater efficiency. A similar explanation probably accounts for many other rather spectacular effects of evolution, but in few cases can we trace the steps so clearly as in this "accidental" evolution of swimming in scallops.

CHEMICAL MESSENGERS

by Dr John Yudkin

THERE are a number of activities—movement, growth and so on—which we regard as characteristic of living animals. In the earliest stages of evolution, all these activities were carried out by the single cell which constituted the whole animal. Later, with the evolution of animals composed of several cells, different cells or groups of cells began to specialize in different activities. Legs were developed for movement, a stomach for digestion, lungs for breathing. From this point onwards, the problem of *co-ordination* began to arise. It became necessary to make sure that the different parts of the animal should carry out their own particular duties in relation to one another, so that the body as a whole could function efficiently. If the animal wanted to run suddenly to escape danger or to catch its prey, it would want to breathe quicker and its heart to pump blood faster, as well as its legs to move more rapidly. It is also of the utmost importance that, in the young animal, the growth of each part of the body is just right and that no part either remains too small or becomes too large for the function it has to perform.

In order to produce such co-ordination of the different organs, animals have developed two methods of communication, whereby information can be transmitted between the different parts of the body. One is the nervous system which we may compare with a telephone system. The various parts of the body are all connected by nerves with the spinal cord and brain, and messages are continuously passing from these parts to the central exchange. Here they are analysed and then transmitted down to other parts, so that each organ can act in co-ordination with all the other organs. The second system of communication is that carried out by the "chemical messengers", and this may be compared with wireless telegraphy. By this method, chemical substances are produced in special organs of the body and poured into the blood stream. This means that they will reach every tissue and every cell of the body, but just as broadcast messages can only be picked up by receivers which are tuned in to them, so these chemical messengers can only influence those parts of the organism which are sensitive to them. Because they frequently increase the activity of these sensitive tissues or cells, they are called hormones, from the Greek word *hormaō*, "I excite".

Organs of the body which manufacture a fluid or secretion are called glands, and many of them, like the salivary glands, have ducts which carry their secretion to the place where it is required. The hormones, though, are poured by the glands directly

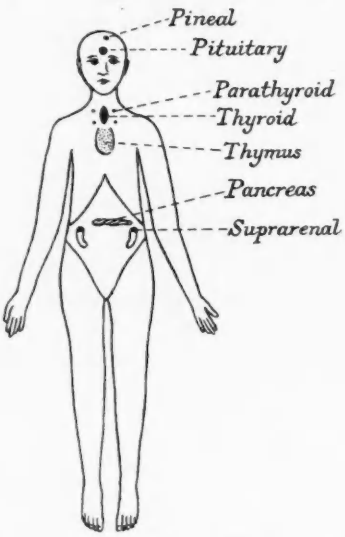


Fig. 1. *The position of the glands in the body*

into the blood which is flowing through them, so that the glands are often called ductless glands and the hormones themselves are frequently called endocrines, or internal secretions. Occasionally, hormones are produced in glands which have a duct; insulin, for example, is made by the pancreas. But the pancreas is really made up of two distinct glands, one producing an external secretion which flows to the intestine along the duct, and the other producing the internal secretion which passes directly into the blood.

There are several methods of studying the actions of these hormones. In the first place, we can perform experiments on animals. We can take out the gland and see the effect on the animal. We can then try and make extracts of the gland and study the effects of feeding or injecting them into these animals or into normal animals. Lastly, if we study carefully certain diseases which occur in human beings, we find that in some of these certain glands are obviously enlarged and overactive, whilst in others certain glands are just as obviously shrunken and inactive. And in most cases, it is possible to combine the clues obtained from human diseases with the results of animal experiments, since we find that the symptoms of the disease are very much like the changes we get in the animals.

As an example of the way in which we can investigate the action of a hormone, let us consider the thyroid gland. The thyroid is situated in the neck, lying across the wind-pipe. If it is removed in young animals, there results a decrease in physical and mental growth and development. The animal remains short and stunted, and is correspondingly dull and lifeless. All the processes of the body are slowed down so that, for example, the temperature and the pulse rate are below normal. Since it burns up its food so slowly, the animal also gradually puts on weight and becomes fat. In tadpoles, removal of the thyroid gland prevents their metamorphosis, so that quite large tadpoles develop which never become frogs. If thyroid gland is fed to these animals, all the changes are prevented and, provided the gland is given continually, quite normal animals develop.

Just as removal of the thyroid gland slows down all the body's activities, so feeding it to normal animals speeds up these activities. The animal becomes lively and energetic, the pulse and temperature go up, and the weight falls. If the gland is fed to young tadpoles, they quickly undergo metamorphosis and, in a very short time, tiny frogs are produced.

Now let us turn to diseases in human beings which are due to disturbances of the thyroid. If a baby is born with insufficient thyroid substance, it grows quite normally for a few months, but then its growth begins to slow down and it develops into a *cretin*. Such an unfortunate child is stunted and flabby-looking, with a pale puffy face, dull eyes and prominent thick lips. It looks, and is, very backward mentally. If it is treated promptly and continually with thyroid gland, these features disappear and it becomes a perfectly normal child. In older

Fig. 2. Twin lambs, aged 16 months. The lamb on the right had its thyroid removed when it was one month old

people, too, a deficiency of thyroid sometimes occurs. These people, who suffer from what is called *myxoedema*, become dull and tired, and begin to put on weight. They have a low temperature, and one of the characteristic features of myxoedema is that the patients are always complaining of the cold. One of these people used to drive about during the summer, wearing a heavy overcoat, in a closed car with all the windows tightly closed. If thyroid gland is taken by these people, they lose all their symptoms and become quite normal.

In both cretinism and myxoedema, the thyroid gland is very much smaller than normal. Typical myxoedema also develops if, for one reason or another, too much of the gland is removed from a patient by operation.

Overactivity of the thyroid also occurs.

Fig. 3. Rabbits, 12 weeks old. The two smaller ones have had their thyroids removed

Fig. 4. *Dogs of the same litter, one year old. When* 2 *months old, the smaller one had its pituitary gland taken out*

There is a disease with the name of *exophthalmic goitre*, which really only means staring eyes and a swollen neck. The swelling in the neck is due to the overgrown thyroid gland which is producing too much of its hormone. In addition to the staring eyes, these people show the effects of the increased speed at which their bodily processes are working. They are nervous and irritable, have a quick pulse and are always complaining of feeling too hot. The fact that they are "burning" quickly also makes them very thin. These people can be cured by an operation in which some of the gland is taken out.

We see, then, that the changes found in people with too much or too little thyroid are very similar to those produced in animals by taking out their thyroids or by feeding them with the gland.

There are several other glands in the body which produce hormones as important as that of the thyroid. Diseases of many of them are also known—either too much or too little of the hormone may be produced. And, as with the thyroid, if there is not enough, it can often be made good by giving the person some of the gland or its extract. Similarly, if too much is present, part of the gland can be removed by operation. But these cures are not always as easy as they sound. For example, the hormones—except that of the thyroid—are usually not effective if taken by mouth, so that persons with insufficiency cannot be cured simply by eating the gland. In these cases, it may be necessary to inject the hormone straight into the blood. To do this, the hormone has to be prepared fairly pure, for the other substances present in the gland are often harmful. There may also be difficulties in the way of removing a part of an overactive gland. For example, the minute pituitary gland is found in a small pit in the skull underneath the brain. It is very difficult to get at by operation, but it has been found possible, by the use of X-rays, partly to destroy the gland in people suffering from an overactive pituitary.

Let us now consider the functions of some of these other glands. The pancreas, or sweetbread, manufactures insulin which is necessary for the proper burning of sugar by the cells. If there is not enough insulin produced, diabetes results. Incidentally, insulin provides a good example of the difficulties which one is up against if the hormone happens to be inactive when fed by mouth. As long ago as 1889, it was discovered that dogs, who had had their pancreatic glands removed, developed symptoms just like those of human diabetes. And so it was clear that diabetes was caused by the lack of some hormone made by the pancreas. Feeding the pancreas did

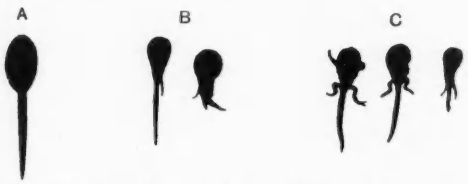


Fig. 5. *The effect of thyroid gland on the metamorphosis of toad tadpoles. All these tadpoles are of the same age. Tadpole* A *has not been treated, tadpoles* B *have been fed with thyroid gland for* 5 *days and tadpoles* C *have been fed with the gland for* 15 *days*

not cure diabetes, and it was not until 33 years later, in 1922, that Banting and Best were able to get an extract from the gland which could be injected into diabetics and which promptly made them better.

The suprarenals are two small glands which are found—as their name indicates—on top of the kidneys. The inner and the outer parts of the glands produce quite different hormones. The hormone made by the inner part or medulla is called adrenaline and is responsible for preparing the body for a sudden emergency. It produces, for example, those changes occurring when you suddenly want to start running, which we described earlier. Your heart beats quicker, your breathing is easier, and a better blood supply is provided for your leg muscles. Although this hormone is very useful, an animal can get along quite well even if the medulla of both suprarenals is taken out. The outer part or cortex of the suprarenals, however, produces a hormone which is essential for life. Animals who have the cortex of the glands removed become very weak and rapidly die. In humans, too, the failure of the production of this hormone leads to the very serious Addison's disease. Within the last few years, an extract from the cortex has been prepared and patients with Addison's disease treated with this are made very much better. The hormone seems to have several functions. It is concerned with keeping the right amount of salt in the blood and, together with insulin, it helps in the control of the sugar used by the body as a fuel.

From Endocrinology

Fig. 6. *A pituitary dwarf. These two children are both* 9½ *years old. The boy on the right is of average height and is about* 15 *inches taller than the little girl*

The parathyroid glands are four small structures found very close to the thyroid gland. Their work is to see that just the right amount of mineral (calcium) is laid down in the bones.

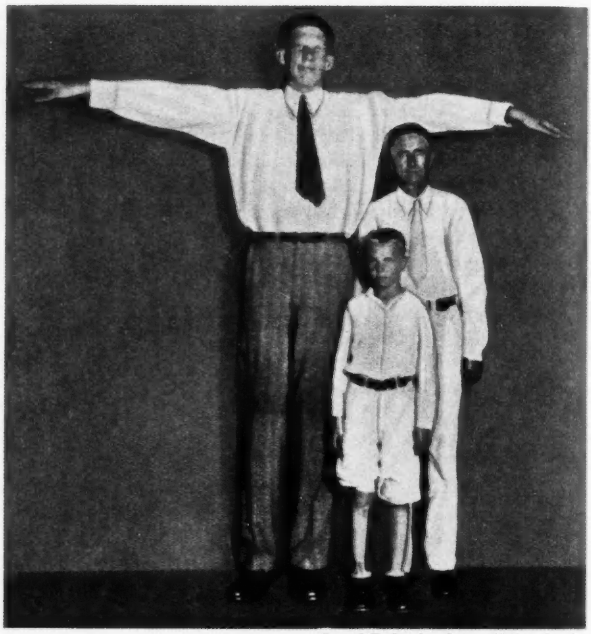
The most important ductless gland in the body is the pituitary. This tiny structure, weighing less than one-fiftieth of an ounce, produces several hormones. One of the chief is that which affects growth. If the pituitary is damaged in animals, or if it does not develop properly in children, they fail to grow. Many of the dwarfs one sees at fairs are people whose pituitary gland is not functioning properly. If too much of the gland is present in children, they develop into "pituitary giants".

But the most interesting thing about the pituitary is that it seems to be in charge of all the other glands and it has been called the "leader of the endocrine orchestra". It appears to manufacture hormones which control the other glands and make them produce more or less of their own particular hormones. For example, among the many things that happen when the pituitary is taken out are changes just like those which occur when the thyroid is removed. And this is found to be because the thyroid gland itself produces less of its hormone when the pituitary is no longer there.

There are other glands in the body about which we know very little, but which may also manufacture hormones. Examples of these are the thymus gland found in the chest and the pineal gland near the brain.

There is still a lot to be found out about these.

As we have seen, the hormones seem to affect most of the important functions of the body. They can make you tall or short, fat or thin. If you have too little of some hormones, you are slow, dull and stupid; too much, and you are quick, nervous and bright. And so you will hear people speak of different "endocrine types" of individuals, suggesting that, even if the glands are working well enough to prevent you having a definite disease, they may still be producing *just* too little or *just* too much of their hormones. It has even been suggested that certain varieties of dogs are really dogs whose glands are not working properly. People have drawn attention to the resemblance between the face of a cretin and that of a Pekingese and say that Pekes *are* Pekes because they haven't enough thyroid. We have to be very careful though in making these comparisons and, in human beings at any rate, we must take care not to start treating people with gland extracts and hormones if we are not certain that they really need them. The glands have so many actions that it is always unwise to give them unnecessarily. And, anyway, if a person otherwise normal happens to be shorter than average, how do we know whether it is because he hasn't enough thyroid hormone or because he hasn't enough pituitary hormone or simply because his parents and grandparents were all short?



From "Endocrine Organs," *Los Angeles*

Fig. 8. *A pituitary giant. The "giant" is* 13 *years old and* 7 *feet* 3 *inches in height. With him is his father,* 5 *feet* 11 *inches, and a younger brother aged* 9

The illustrations 2, 3, 4 *and* 5 *are published by permission of Miss G. M. Sharpey Schafer, and the Trustees of Sir Edward Sharpey Schafer, from whose books* Endocrine Organs, *Vols. I and II, they are taken.*

Book Reviews

Mankind in the Making

THIS is much the best of the books* I have ever seen for giving a taste and an introduction to pre-history. It is admirably illustrated and wonderfully cheap. One can hardly review it better than by giving short extracts and naming the sort of coloured pictures and drawings which come on almost every other page. The writing is clear and attractive without ever falling from the level of good sensible English which any adult would enjoy reading, without feeling that he was being talked to as a child. Yet any average intelligent child—say of eleven plus (in the present official jargon)—could read the book without the least difficulty. Perhaps the best plan would be to give Mr Borer's introductory sentences just as they stand.

"How did we all begin? Why is it that we walk on only two of our limbs, in an upright position, instead of prowling about on all fours? How is it that we have the power to direct our hands and lift our food to our mouths instead of nuzzling down to it and chewing it straight off the ground? Why do we bother about complicated things like houses, dining-tables and knives and forks?... If you have had the inside of a motor car or a wireless set explained to you, you may feel that you know a great deal of how the world works today, but if you ask yourself these more fundamental questions, you will find that, after all, you know practically nothing at all of the processes of nature of which you are yourself a part.

"One of the most important ways of learning about a person, or a country, is to read its history. So it is with mankind. To understand what is going on now we must learn what has happened in the past.... It is only for the last five or six thousand years of its life, however, that mankind has learnt to leave written accounts of his activities, and man himself has a history of nearly a million years. It is equivalent to saying that we know all about the last five minutes, but not what happened during the first sixteen or seventeen hours."

There you have in perfectly true, simple and striking language the case for teaching pre-history as an essential part of the history studies which everyone should enjoy and which have been so ludicrously mangled or omitted in the past. Such a sketch as Mr Borer gives us is still wanting in most school curricula. History even in the narrower sense is still the Cinderella of our school courses. In the wider sense in which Mr Borer opens it up to us it is almost unknown or regarded as a useful field study for the enthusiastic few.

To say that this book is as interesting as a novel would be faint praise. The first chapter should thrill the most hardened reader of detective stories. "We must remember that there is at work in nature some mysterious force which neither physicians, botanists nor chemists are able to explain—the force of life." Then we have some account of the supposed origin of the solar system before we reach the ancestors of man in the second chapter. The geological summary at the end of the first chapter is extremely well done, taking us from the Lifeless Era when the earth was very young and its thin crust continually wrinkling and cracking, down to the Pleistocene Era of recent life and the Age of Man. It is interesting to the botanist to notice that the forest trees which grew in the second interglacial period were remarkably like those we know to-day. It is a proof that Europe was enjoying a mild, pleasant climate a little warmer than we have now, and it was the time at which the first creature we can call a man put in an appearance in Europe. The trees seem at that time to have become much like our own, and one notices that about that time men began to make things with their hands. The very earliest men —of Java and Heidelberg—have left no evidence that they were capable of tool-making, though disputes constantly arise as to the nature of what are called "eoliths". What is certain, however, is that later on in the second interglacial age there were tool-making creatures living in a land full of firs, maples, beeches, oaks, even vines, clematis and fig trees. And you may date that age from anything above half a million to a million years ago.

Then we have the accustomed series of prehistoric types but put more shortly and vividly than in most of the longer books on pre-history. We are reminded, for instance, that the Neanderthal man, who follows the rather vague figures of Chellean, Acheulean and Mousterian types, formed mainly from a fragment of his skull, was the first to fix arrow-heads to shafts; that in his age life in the caves promoted social development, that he buried his dead with weapons and food for use in the other world.

* *Mankind in the Making*, by M. Cathcart Borer. Warne, 3*s*. 6*d*.

The Cro-Magnon type which comes at a later stage, hails from Asia and with them we have the first mention of the cave paintings which are so marvellous a product of our remote ancestors. How far however we may regard them as actual ancestors still appears to be a much vexed question. It must be remembered that the whole science of pre-history is barely a hundred years old. In another hundred years, if science survives this war, we shall be overwhelmed by the details of our knowledge, and it is because Mr Borer gives such a clear outline with such significant facts that we heartily recommend his book. Every one is attractive and leads one on with the confidence of following an expert guide.

It would be a shame to extract more plums from this detectable dish. Every school library should possess it, and most older people would do well to feast on the excellent books which are now being provided for the younger generation. Any child who possessed or read this book would be in a better position to judge of the origin and meaning of Stonehenge than nine-tenths of the adults who pass it in their motor cars.

Who were the people who first invented pottery?

Which was the first of our domestic animals to become attached to us?

Where in the world do we find most relics among living men of the habits of our pre-historic ancestors?

Which of these pre-historic men are most likely to be the stock from which the present population has descended?

Here are a few of the fascinating problems which find an answer—provisional at least—in Mr Borer's book.

So make haste to read it, if you have intelligence enough to wish to take your place—looking backward to forward—in the history of the leading animal species of our planet.

F. S. MARVIN

Food Values at a Glance

IN the small compass of this book* something will be found to interest many types of reader. It sets out to tell us, simply and in a readable manner, the kinds of foodstuffs which are essential, the relative proportions in which they are needed, the quantities required and the purposes for which the body needs them. There is also a section dealing with the problem of catering for schools and institutions. One is so accustomed to having the cookery of the Continental housewife held up as a model of all that is admirable, that it is refreshing to hear that the simple methods of her English sister are better from a nutritional point of view, since they are more likely to preserve the food values. Those who are addicted to using a tin-opener will also be cheered to read this book, for the habit has the author's blessing. There are many tables and charts. Whatever else may be passed over the latter will be studied with interest, for they are brightly coloured and compel attention. Here one can see at a glance the relative proportions of the main food constituents of a large and varied collection of "eatables". As we are dependent upon animals and plants for our food supply, it is right that the book should include a plea for a return to more natural feeding of animals and a warning of the dangers of continual withdrawal of nourishment from the soil without proper repayment. "Animals and human beings fed on ill-nourished plants are likely to be ill-nourished and subject to disease."

A book on food would be incomplete unless it at least touched on problems of agricultural policy, cost and distribution of food, housing schemes and poverty in general, and the author has something to say on all these topics.

There are several trite statements which would have been better avoided unless they could have been elaborated. The classing of cancer and diabetes as diseases of over-nutrition is too easy a way of disposing of them. We do not yet know the causes of cancer and there is more than one type of diabetes, one of which appears to be connected with anxiety and worry. But perhaps the author would maintain that anxiety over one's bank balance, etc., is really a question of malnutrition!

E. W.

* *Food Values at a Glance*, by V. G. Plimmer. Longmans, Green and Co., 6*s*.

Dersu

V. K. ARSENIEV was a Russian explorer engaged by the Tsarist government, and later by the Soviets, to map the mountainous regions of Ussuria, a province in eastern Siberia. His book,* which tells the story of several expeditions made in the early years of the century, combines the virtues of a scientific record of vegetation and topography with a good first-hand account of life in a little-known backwoods area. Possessing both botanical and geological knowledge and a real feeling for scenery and wild nature, Arseniev draws an impressive picture of the *Taiga*, the great belt of Siberian mixed forest through which most of his journeys were made. Here are giant poplars and cedars, dense undergrowth, concealing game, tigers, and other wild life, with here and there lilacs forty feet high and four in girth;

* *Dersu the Trapper*, translated from the Russian of V. K. Arseniev by Dr Malcolm Burr, B.Sc. Secker and Warburg, 15*s*. net.

here too are a few sable trappers and Chinese farmers earning a precarious livelihood by cultivating, or collecting, scattered patches of ginseng, a plant something like a mandrake, which is locally believed to have rejuvenative and general curative powers. But all this geographical detail is really only a background; against it moves the central human figure of the book, Dersu Uzala, one of the vanishing tribe of Siberian Golds, who walked into Arseniev's camp one night with all his possessions on his back, armed with an old Russian rifle that he had inherited from his father, and which was fired from a prop. Dersu managed by accident or design to join all the later expeditions, and proved his worth not only by his skill as a hunter and guide, but also by saving Arseniev's life. Dersu is an unusual and attractive figure, hating the settled life of towns and clinging firmly to a peculiar anthropomorphic view of the world, applied impartially to animals, plants, and firewood, and even to the phonograph on which Arseniev recorded and played his voice. Arseniev treats his friend and guide with real sympathy and the deep respect of one expert for another who was his master. With Dersu as its hero Arseniev's book presents an excellent picture of a region unfamiliar to most English readers and previously untouched by travel literature. Gorki compared it favourably to the work of Fenimore Cooper; the comparison is just, and Arseniev has the advantage of new country and real adventures to describe. The book has three rather sketchy maps, which might have been improved by the addition of the routes of the various expeditions; there are also a number of small and sometimes scrappy drawings. Dr Malcolm Burr's translation is fluent and sensible, in spite of the obvious difficulty of turning Dersu's pidgin Russian into a satisfactory English equivalent; indeed one tends to pay it the highest compliment that can be paid to a translation by not noticing it at all. This book can be recommended to readers of any age who enjoy hearing of real adventures or who like to get the feel of life in strange and lonely places.

C. F. E.

Theory of Probability

IT is unfortunate that scientific method has largely developed without much consideration for logical foundations, and there is little relation between three main groups of workers—philosophers, statisticians and physicists. The work of Dr Jeffreys* goes beyond providing a philosophical basis of probability; it is concerned with scientific inferences from observational data that will be both consistent and capable of practical application. A serious difference in point of view exists between the physicist and the statistician. The former claims that he is able to prove his hypothesis by the assistance of observations, but an obvious logical fallacy appears in this claim, because there are generally other hypotheses which are consistent with the data. In contrast with the claim of the physicist is that of the statistician who regards observations as a basis for the possible rejection of hypotheses, not for supporting them. The attitude of the physicist would make it impossible for hypotheses to be altered, however much they were unsupported by new evidence. On the other hand, if the attitude of the statistician were adopted, all inductive inferences would be reduced to guesswork.

Dr Jeffreys rejects the attempt of both schools to reduce induction to deduction and maintains that "the ordinary common-sense notion of probability is capable of precise and consistent treatment when once an adequate language is provided for it". The correct method of scientific inference lies between the two extreme views of the physicist and the statistician, and a precisely stated hypothesis can attain a high or a negligible probability from observational data. The basis of the theory underlying the work appears on pp. 8–10, where Rules are laid down "largely suggested by the procedure of logicians and pure mathematicians". Five of these are essential and three others are referred to as "useful guides". Although the rules may seem to be mere platitudes (the author has no objection to this view), they require the rejection of a number of principles which have been accepted as fundamental in other theories. Rule 3 eliminates the Venn limit, the hypothetical infinite population of Fisher and the ensemble of Willard Gibbs.

Fundamentally, the theory is that of Bayes and Laplace, with some modifications in their hypotheses before certain types of cases, which were not considered by them, can be treated. Dr Jeffreys has applied the theory to most of the main problems of statistics, and examples have been taken from a number of subjects, more especially from physics and geophysics. As might be expected from the author's chief interest, the theory was primarily developed with a view to geophysical applications. He tells us in the "Preface" that "the most beneficial result that I can hope for as a consequence of the work is that more attention will be paid to the precise statement of the alternatives involved in the question asked". There should not, he holds, be any paradox in considering that the answer depends not only on the observations but on the question; it is, in fact, a platitude.

* *Theory of Probability*, by Dr Harold Jeffreys. Oxford Univ. Press, 21*s*. net.

Prose of Purpose

THIS is a remarkable little book* with an arresting and well-thought-out title. It would be impossible for any intelligent person, say over the age of fifteen or sixteen, not to enjoy it and yet it is difficult to describe. It is about everything and it draws its extracts from some three-score eminent writers. With the exception of four they are all English and range from Dr Johnson to Mr J. M. Keynes. The book has been compiled primarily for older scholars at school but, like so many good school-books nowadays, it is delightful and inspiring reading for any one. The compilers in their Preface give us a hint of what they had in mind when they say that "the English course has been dominated by too narrow a conception of literature", and that "scholars leave school with little knowledge either of the civilizations of Greece and Rome on which our culture is based, or of scientific method and discoveries which have profoundly affected modern life and thought". One might say that in their choice of extracts they have had in mind throughout the broadening, deepening and humanizing of the education of the rising generation. The first section deals with poetry and opens with Wordsworth's famous answer to "What is a Poet?" The second has half a dozen striking passages on good writing generally. Then follows an admirable section on the great turning points in the history of science, including what Newton and Harvey said about their own discoveries and ending with some modern reflexions on the effect of science on our present civilization. This leads naturally to some admirable chapters (or rather extracts from writings of Mr J. M. Keynes and J. L. Hammond) on the use and the dangers of the increased leisure and resources which science affords. Clearly man must turn to art of various kinds and aim at making more beautiful the world into which he has been born and of which his intellect has given him the command. Here there is a return to Athens, and there is the suggestion (nothing is thrust down our throats by the compilers themselves) that the beauty and majesty of the Greco-Roman world at its best should give us guidance now that the problem has become one for all the world. To preserve the best in the past and to extend its enjoyment is the underlying thought. Then we have some passages on the folly, horrors, and yet accompanying heroism of war. Here some moving extracts occur on the fate and character of the British soldier. King George V's address after his pilgrimage to the graves of the fallen in the Great War reads with extraordinary power at the present moment, and one is introduced also to a writer of English whose works are far less well known than they should be—that is, Professor Macneile Dixon, who was for many years in charge of the English Department at Birmingham and was thence promoted to Glasgow and to the Ministry of Information. He gave the Gifford Lectures in the years 1935–7 on The Human Situation, and his short monograph called *The Englishman* should be a classic in the possession of every one. The compilers give us his chapter entitled "Shakespeare the Englishman", which is as inspiring as it is original.

The book ends very suitably with Lytton Strachey's passage on the death of Queen Victoria, and with some moving words from Robert Bridges' "Spirit of Man", which, written during the Great War, finds a similar response in the struggle and perplexities by which we are now assailed.

The value and attractiveness of the book will be readily perceived even from the inadequate account which we have been able to give of it. It should not be dismissed merely as an anthology of English prose. It certainly deserves that description, but it is far more also. It has a connecting link and a high purpose. We are said to be wanting as a nation in the appreciation of ideas. Here we have them culled from English writers and linked together by the desire to keep alive the best in Western civilization and make our scholars enthusiastic for something which they do not glean from their ordinary text-books. But let everyone enjoy it, outside the school walls rather than within. It would be difficult to find so much good stuff in any 250 pp. elsewhere. F. S. MARVIN

* *Prose of Purpose*, by A. Law, J. W. Oliver and H. J. L. Robbie. Oliver and Boyd, 3*s.* 6*d.*

Correction: page 82 line 21, (Vol. III, No. 23), should read "...*amino-* and *imino-acids*...."

Select List of Books Received by *Discovery*

(*Mention in this list does not preclude review*)

Two Roads to Africa. H. E. SYMONS. (Scientific Book Club, 3*s.* 6*d.*)

The Wandering Lake. SVEN HEDIN. (Routledge, 18*s.*)

Scott of the Antarctic. GEORGE SEAVER. (John Murray, 10*s.* 6*d.*)

Tight Corners. SIR ALAN COBHAM, J. L. LONGLAND and OTHERS. (George Allen and Unwin, 7*s.* 6*d.*)

This Strange World. A. E. TRUEMAN. (Scientific Book Club, 3*s.* 6*d.*)

Environment and Heredity. OLIVE D. MAGUINNESS. (Nelson, Discussion Books No. 36, 2*s.* 6*d.*)

The earth is being bombarded continuously by super-power particles, the energy of which rises to at least 20 billion *e*-volts. A hundred or more such particles shoot each minute through the head of every person living on the earth....
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